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BAYER LEVERKUSEN (GERMANY)

Department for Plant Protection

Trial Controls of Larch Insects by Injecting Trees with Systemic Insecticides

by Dr. J. P. Vité, Göttingen University

The idea of incorporating certain chemicals into a plant by means of injection is so obvious that there has been no lack of tests carried out to put it into practice. Such tests were conducted in the past for various purposes in accordance with contemporary methods and means, and the know-how of the particular era. Details of methods applied to introduce odorous substances or chemicals into fruits via the sap stream or to colour roses artificially in the same way, may be found in the literature of the 12th century. Better known are the 15th century experiments of Leonardo da Vinci, conducted in an attempt to poison the fruits of a tree by introducing arsenic solution into the trunk (cf. Roach, 1939). The idea of freeing a plant of its parasites by means of injection, is also very old. It was stated that the application of a mixture of "pepper, laurel, incense and good wine" into the trunk through a hole bored in it would kill the insects in the trunk (anonymous, 1602), and Wilson (1765) reported that by instilling mercury into a bored hole, the insects infesting a plum tree were killed firstly in the bored bough, and later also in the other boughs. In keeping with the progress and increased activity in research on natural science, tests were begun at the end of the last century, aimed at ridding plants of fungi and insects by injecting them with more suitable substances, or else to counteract a deficiency disease. The test plants were exclusively agricultural or horticultural plants, and among the preparations used, preference was given first of all to potassium cyanide and nicotine for controlling insects (Berlese, 1901). In a monograph published in 1926, bearing the programmatic title "The Inner Therapy of Plants", Müller gave a survey of reports from the literature and details of his own tests in this field; however, he did not then arrive at any practical results. A short time later, Jancke (1931) crushed the hopes set on nicotine in a resolute paper, in which he stated that "among the substances used to date, there is none which for the time being meets with the conditions of practical application, namely to act on the parasites by repelling or killing them yet at the same time preserving the health of the plant". In the past few years, not only have such substances been discovered but also very suitable compounds have been marketed (Jancke, 1951 and 1954).

Aside from this development, the impregnation of trees by means of the sap displacement or Boucherie method attained practical importance at a very early stage (patented for A. Boucherie, 1841). Although this method involved the treatment of green, but felled timber, it was only a short step to the attempt at replacing sap displacement by utilizing the sucking action of transpiration on the growing trunk. This was first tried for the purpose of

wood preservation by Wislicenus (1937), Schmittutz (Mahlke-Troschel-Liese, 1950); despite more recent endeavours (cf. Plankl, 1955), the results obtained have so far proved to be unsatisfactory. For forestry purposes, impregnation of growing trees proved to be somewhat more suitable both for chemical girdling (cf. Gläser, 1955) as well as for the control of engraver beetles. This method was applied with good results against *Ips typographus* L. in separate trials conducted by Lekander (1951) in Sweden, and by Wellenstein and Postner (1954) in Germany. Previously, Bedard (1938) had tried the same method against *Dendroctonus monticolae* Hopk. on pines. However, if the girdling of the tree and the application of poison to the exposed girdle, with chemical barking, leads to the trunk perishing and drying up as required, this will amount to an unavoidable but by no means desired attendant phenomenon to the engraver beetle control. In contrast, the methods of inner therapy are designed to preserve the plant.

Injection is but one of three possibilities of incorporating systemic insecticides into the plant, and, appear as it may, in comparison with absorption through the roots or the assimilation organs, it is the less significant in plant protection practice (Unterstenhöfer, 1953). It necessitates individual treatment, a procedure which must be ranked as inferior to group treatment particularly in agricultural plant protection. In the case of tree cultures, the situation may of course be quite different, with the individual trunk treatment being preferable to area treatment for various reasons. From the section of forestry protection against insects, a number of such situations are known in which the single trunk treatment is imperative for reasons of profitableness, expediency from the biological aspect or because of the effectiveness of the control technique. Examples of this are the controls of noxious insects in mixed cultures, particularly when the infested tree species is planted singly along with other species, the control of harmful insects which occur in masses only on single trunks (e. g. the beech scale, *Cryptococcus fagi*), or finally the control of engraver beetles.

Apart from the conditions in young cultures, the procedures necessary for carrying out single trunk treatments are nevertheless complicated, and are often burdened with undesired attendant phenomena. It is either a case of treating by fog application the assimilation surface of the individual tree, which often cannot be done with only one apparatus, or to spray or atomize the tree with high-pressure sprayers and long rods. In other cases, the poisoning of the trunk in a similar manner or with poles and brushes is just as time-wasting and expensive.

In many cases, it would, therefore, be a considerable advantage if previous methods could be replaced or supplemented by a more simple poisoning practice which above all is not dependent upon the weather. The discovery that several of the systemic insecticides penetrate through the bark of the trees, led to the application of the "banding method". In this method, a layer of absorbent material, soaked with the insecticide, is applied to the trunk of the tree requiring treatment. The preparation penetrates through the bark to the transpiration stream, is translocated by this stream, and spreads to all parts of the tree top. This method developed by Jeppson, Jesser and Complin (1952), and applied experimentally by Bond (1953) and Jancke (1954), led to apparent success being achieved against sucking insects. The application of the

same method also proved successful against two noxious insects, the larch casebearer (*Coleophora laricella* Hb.) and the larch thrips (*Taeniothrips laricivorus* Krat.), occurring simultaneously on young *Larix*, when high concentrations of the systemic insecticide "Metasystox", were used. This method rendered it possible to carry out the otherwise difficult joint control of the two larch pests (Vité, 1955). This method was also tested as a control measure against *Taeniothrips laricivorus* occurring on its own (Martignoni and Zemp, 1956).

Compared with applications in market gardening and agriculture, the use of this method in forestry has the advantage that it does not involve the tricky problem concerning the accumulation of toxic substances in harvest produce which is used as food. The costs and intricacy of the banding method, and also variations in the effect, made it necessary on the other hand to strive for a further development of the practice, which was then tested, occasionally also on tree species other than the larch, against different insects and with a varying degree of success. The methodical development, however, remained restricted to the treatment of the larch and the control of the two more important larch pests. Morphological and physiological peculiarities of this tree species (the wide cross-section of the tracheids and relatively heavy transpiration), in combination with the behaviour of the two insects*, make it a particularly favourable research object for the application of systemic insecticides.

These studies were supported by the German Research Association and the Forestry Division of the Ministry for Food, Agriculture and Forestry of Lower Saxony.

The Banding Method

The banding method has, to a certain extent, a predecessor in the "sleeve method" developed by Schewirjeff (cited after Müller, 1926) at about the turn of the century. This is a very intricate method in which an aluminium sleeve is placed around the trunk. The bottom edge of the sleeve has to be cemented on to the smoothed bark. The liquid is then poured into the open top of the sleeve, and the absorption of this liquid is accelerated or facilitated by one or several narrow punctures being made by means of a chisel in the bark below the level of the liquid. The method was used chiefly for staining tests. In the banding method, instead of the aluminium sleeve, a strip of absorbent material, usually cellulose, the width of a hand, is wound around

* Among the noxious insects occurring on larches grown in Central Europe, the larch casebearer and the larch thrips have developed into troublesome attendants of this tree species which from the silvicultural aspect, is difficult enough anyway. In contrast to the other larch insects which only show a tendency towards local or temporally restricted mass reproductions, the injuries inflicted by larch casebearer on European and Japanese larches, and by the thrips chiefly on European larches are of a chronic nature over wide areas. As both pests often occur together on young larches, they easily create critical situations both by reduction of the assimilation surface as well as by inhibition of height growth especially in mixed stands. For these reasons, a suitable control method has been sought for several years past, which can be applied against casebearers as well as thrips, and which can be varied depending upon predominance of one or the other pest. The greatest difficulty is that the thrips only colonizes the larch for a relatively short period of the year, and when it does then only on newly grown plant parts, whereas the casebearer, firstly in the egg stage and later as a mining egg larva, is not exposed to insecticides lacking a systemic action.

the trunk, with a correspondingly wider strip of plastic foil placed over it to give protection against evaporation; after the cellulose has been soaked with the insecticidal emulsion, the plastic foil is also tied around the trunk above the cellulose band. Any form of pre-treatment on smooth-barked trunks is superfluous. On trunks with rough or cracked bark it is advisable to remove the bark scale with a steel-wire brush, while on old trees reddening is necessary. In no cases, however, is it possible to completely prevent over a long period the penetration of rain-water, particularly on the side exposed to the weather, resulting from the trunk dripping, which in turn leads to the emulsion becoming diluted or the active ingredient being washed out of the band. A polyethylene or polyvinylchloride (Igelit) strip, however, largely prevents evaporation, and when the banding is done very thoroughly, as specified by Martignoni and Zemp (1956), the loss of active ingredient should be relatively insignificant.

Trial controls carried out by means of the banding method from 1953 to 1956 at various locations, on different tree species and against different pests, were at first only slightly successful with the exception of those conducted on larch trees.

Spruce: The trunk treatment of eight-year-old spruces with 5 and 10 % "Systox" neither prevented the formation of galls by *Chermesiden Cnaphalodes strobilobius* Kltb. and *Chermes (Adelges) abietis* L. nor killed the larvae present in the galls. This result conforms with a report of Wachtendorf (1954), according to whom a spray application of 0.05 % "Systox" and "Metasystox" had no effect on *Ips typographus* L. which had been made to colonize on the tree by artificial means 50 to 150 cm above the band. Spray treatments of trunk sections, carried out by way of comparison with 2.5 and 1 % "Metasystox", also had no effect on the same pest species and their breeds, with the exception of a few killed in the breeding gallery.

Firs: Trunk treatments carried out at the end of June and the beginning of July on 20-year-old firs (grown to the average height of a man) and on fir tree timber, using 0.5 to 4 % "Metasystox" against the fir needle aphid, *Dreyfusia nüsslini* C.B., only gave good results on new growth at concentrations above 1.5 % (Vité, 1956).

Larches: The comparative application of "Systox" (diethylthionophosphate of β -oxyethyl-thioethylether) and "Metasystox" (dimethyl ethyl mercaptoethyl thiophosphate) by means of the banding method on *Larix decidua* and *Larix leptolepis*, very soon revealed the clear superiority of "Metasystox" (Vité, 1955) which is absorbed more quickly by the plant (anonymous, 1955). "Metasystox" produced a good effect on 10 to 15-year-old larches when applied as a 5 % emulsion, and a varying but adequate effect at 2.5 to 4 % under different climatic conditions against the egg larvae of *Coleophora laricella* and *Taeniothrips laricivorus*, also against aphids (*Chermesidae*). Egg larvae of *Coleophora laricella* mining in the needles proved to be more susceptible than those of the larch thrips. In the Summer of 1954, the application of only 1 % "Metasystox" actually led to the partial extermination of the casebearer larvae. The effect produced against the imaginal stage and the second larval stage of *Taeniothrips laricivorus* was not convincing, while the trunk treatment carried out in Spring using concentrations of 1 to 5 % against casebearer larvae of the 2nd to 4th stages, was unsuccessful. Furthermore, the larvae of *Laspeyresia zebeana* Rtzb. living in the galls were not affected, and a fungicidal effect

against larch canker, *Dasyscypha willkommii* Htg., was not observed even at higher concentrations of 7 to 10 %.

In the meantime, similar results were obtained by Martignoni and Zemp (1956) who applied the same method against larch thrips on 14-year-old European larches in the Wegenbach district of Schaffhausen (Switzerland). Following an application of 5 % "Metasystox" at the beginning of July, 1955, all the terminal buds and leading shoots remained green, and the average height growth was greatest on these larches. Following a treatment with 2.5 % emulsion, more than 75 % of the terminal shoots and buds remained green as compared with 20 % on the untreated larches.

The varying effects obtained in the trials conducted therefore confirm the theory of Unterstenhöfer (1955) in respect of inner therapy, that "only means with a wide range of deviation and a narrow range of validity can be obtained only for certain pest species on certain plant species or even varieties, because the conditions constantly change from test to test, and consequently the same group of factors can never be produced or encountered, or at the most only similar factors". In order to exploit in practice at least the obvious advantages of this method for the joint control of larch casebearers and larch thrips, further trials were conducted which revealed the approximate limits of the range of validity:

1. In the past three years, the end of June to the beginning of July has proved to be the best time for carrying out a control. Depending upon the weather, the effect clearly sets in about ten days after the application of the band, and remains persistent for several weeks. The moist, cool weather in July, 1954 was more favourable than that in July, 1955 when despite the heavy rainfall there were very many warm days.

2. Using the same quantity of cellulose, the narrower cellulose strip, up to about 10 cm wide, should be given preference over the wide band. Approximately 100 ccs of emulsion are required to 10 g of cellulose. The quantity of insecticide needed to ensure successful poisoning depends upon the object requiring treatment, in other words upon the assimilation surface area and the volume of the tree. Practically speaking, an estimate can be made only from two dimensions, the height of the tree and the thickness of the trunk.

According to the detailed studies of Martignoni and Zemp (1956), which were confirmed by the author's own observations, there is not so much a correlation between the height of the tree and the quantity of insecticide needed as between the thickness of the tree and the poison requirements. The trunk diameter is a value the square of which is approximately proportional to the volume of the tree. Not only the quantity of emulsion but also the concentration must be raised proportional to increases in the thickness of the tree measured as the diameter at breast height. The values given below represent coefficients gained from local experience, which were obtained from a relatively small trial group of several hundred trees. They are based on both European and Japanese larches, and on the joint control of *Coleophora laricella* and *Taeniothrips laricivorus*.

A visible effect may be expected in the upper parts of the crown, particularly against the casebearer, at the lower dosage limit according to the given data, even under less favourable climatic conditions. The larger dosages generally lead to a complete elimination of injuries at the two smaller tree diameters and

Diameter at breast height	Concentration "Metasystox"	ccs of preparation	ccs of emulsion
up to 10 cm	5 %	6—10	120—200
10—15 cm	5 %	10—15	200—300
15—20 cm	10 %	18—25	180—250
20—25 cm	10 %	30—40	300—400

to an appreciable reduction of injuries in the two larger diameter groups, although at these latter diameters a complete elimination of both pests is not always attained.

3. The poison is not uniformly absorbed and distributed in the tree. At equal diameter, trees with broad annual rings and strongly developed assimilation surfaces appear to absorb the emulsion better than those with weakly developed crowns. Likewise, the translocation of the active substance varies, being greater in the top and in well-developed boughs and branches, and less progressive in lower parts of the crown which are weaker from the transpiration-physiological aspect. This observation corresponds to the basic finding of Huber (1926—28) on *Abies concolor*, according to which the relative conducting surface increases considerably towards the top (in this case almost tenfold), resulting in a strong apical boost of the water transport.

Consequently varying degrees of effectiveness are registered inside one tree. Lateral branches with very little foliage and correspondingly low suction power, sometimes do not absorb sufficient active substance especially when the dosage is small which is quite understandable, so that the dosis letalis is not produced in them, and the casebearer larvae remain alive, while the rest of the tree is freed from the pests. In the following Spring at the time when the greatest damage is caused by casebearers, we encounter a peculiar sight on such larch trees, in that the healthy and fully foliated crown is intermingled with several branches coloured brown as the result of more or less serious injuries inflicted by casebearers. Furthermore, there also appear to be varying toxic values and degrees of efficacy in the different types of needles. The impression is gained that the casebearer larvae are killed more quickly in the young and stronger long shoot needles than in the dwarf shoot needles of the same branch. If correct, this would coincide with observations of the rate of action of "Systox" on differently aged leaves of cultivated plants (cf. Unterstenhöfer, 1955). Generally speaking, the effect is, therefore, better and more rapid on better supplied parts of the assimilation surface, as a rule the top and upper crown, than in the lower parts of the crown.

4. Appreciable secondary effects were not observed with the trunk treatments described and at the concentrations used. Neither phytotoxic injuries were inflicted on the larches nor was the remaining fauna affected. The bound-up section of the trunk merely showed bulges after the band had been left on for one year, and especially in cases where it was left on for two years. These bulges were not the result of a tendency on the part of the very elastic band

to shrink but must have been caused by other factors probably due partly to the high rate of humidity inside the band especially on the side where the trunk drips. On young larches with a smooth bark, these bulges are made more obvious due to cracks in the bark, formed under the influence of locally increased growth of the xylem during the time the band is on the trunk (Fig. 1).

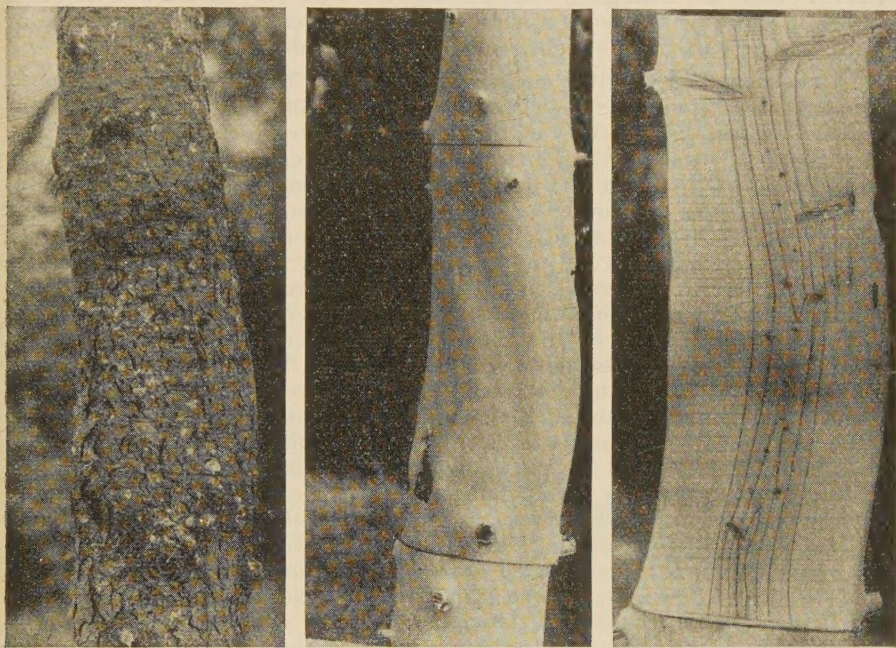


Fig. 1: Change (bulging) in trunk section of a 12-year-old European larch with band applied for two years

Cartridge Injection

The complicated nature of the banding method automatically led to efforts being made to improve the method. A basis to work on was the fact that the systemic insecticides used were able to diffuse through the unharmed bark. Consequently it appeared likely that direct application in the transpiration stream at one point of the trunk would lead, in addition to the direct translocation to the affected parts and their fibre flow, also to a distribution in the other parts of the tree. It was not clear, however, whether the diffusion would suffice to supply all parts of the tree with poison on an adequate scale.

The application of substances into the assimilation stream can be effected through the trunk, roots or branches. There are numerous methods of long-standing for doing this. On trees, the oldest but most practised method is the

application of the substance into one or several holes bored in the trunk or root, which can be done with the aid of funnels (Tschermak, 1896 et al.) or tube systems (Roth, 1896) which are placed in the holes. Similar complicated methods in which holes were bored or cuts were made with chisels in a manner which, unnecessarily, would prevent the admission of air (it being believed that in this way the suction action of the transpiration stream would be maintained [cf. Roach, 1939]) (Schewirjeff, Mokrzejcki, Rumbold, Walton cf. Müller, 1926), are technically impracticable from the very outset. For the same reasons it appeared that only a method permitting applications to be made at easily reached parts of the trunk could be considered.

A likely method was that suggested by Müller (1926), to immerse topped branches after pruning in a vessel containing suitable liquid. A certain degree of success was obtained with this method on deciduous trees, and Müller, therefore, regarded it as one of the most promising. Roach (1939) later conducted several experiments using the same method, namely the branch-tip injection. Stainings on fruit trees showed that a translocation from the point of injection into the trunk only takes place, however, when the bough is old and strong, and has been cut off close to the trunk. On the other hand, the injection of lateral branches some distance away from the trunk only leads to a restricted distribution of the applied substance within the treated bough. This was confirmed by tests the author conducted on beech trees and larches. When the main axis of boughs approximately 1 m long and bearing lateral branches, was cut off in the centre and the cut surface was immersed in stain liquid, it was found that the staining only appeared in a ring around the bough in the region of the cut surface. It is only on the branched sides that stains run from the region of the cut surface to the next strong lateral branch or branches, and then along these only to end completely at the axis of the bough (Fig. 2). According to the author's observations, the incorporation of substances through cut branches depends upon the thickness of the topped branch in proportion to that of the lateral branches located nearer to the trunk, and upon the distance from the point of injection to the trunk. In other words, it is only when the cross-section of the cut surface is appreciably larger — about twice as large — than the sum of the base cross-sections of the lateral branches located nearer the trunk, that the infiltrated substance can be expected to be carried into the trunk axis. This fully corresponds with similar findings made by Roach (1939). This method, too, was rejected because it could only be used for very young cultures. The application of stain to sturdy lateral boughs growing right up against the trunk only led to a moderate penetration into the trunk. Consequently another method had to be found to incorporate systemic insecticides in the transpiration stream without damaging the trunk. A possibility was seen in fixing containers with small openings to the xylem.

Preliminary tests were conducted at the beginning of July, 1955, in a twelve-year-old larch plantation of the Forestry Training District, Kattenbühl, and in an eight-year-old larch culture of the Municipal Forestry Office, Hann.-Münden, using the following procedure:

The bases of cartridge cases with a bore 9 mm in diameter (ordinary carbine cartridges) were sawn off, and the cartridge cases were connected by means of tubes to poison containers. The cases were either hammered into the trunk direct or else a piece of bark and cambium corresponding to the size of the cartridge bore was removed, and the case fixed to the xylem. The number of cartridges used varied between 1 and 4 per trunk. Whenever more cartridges

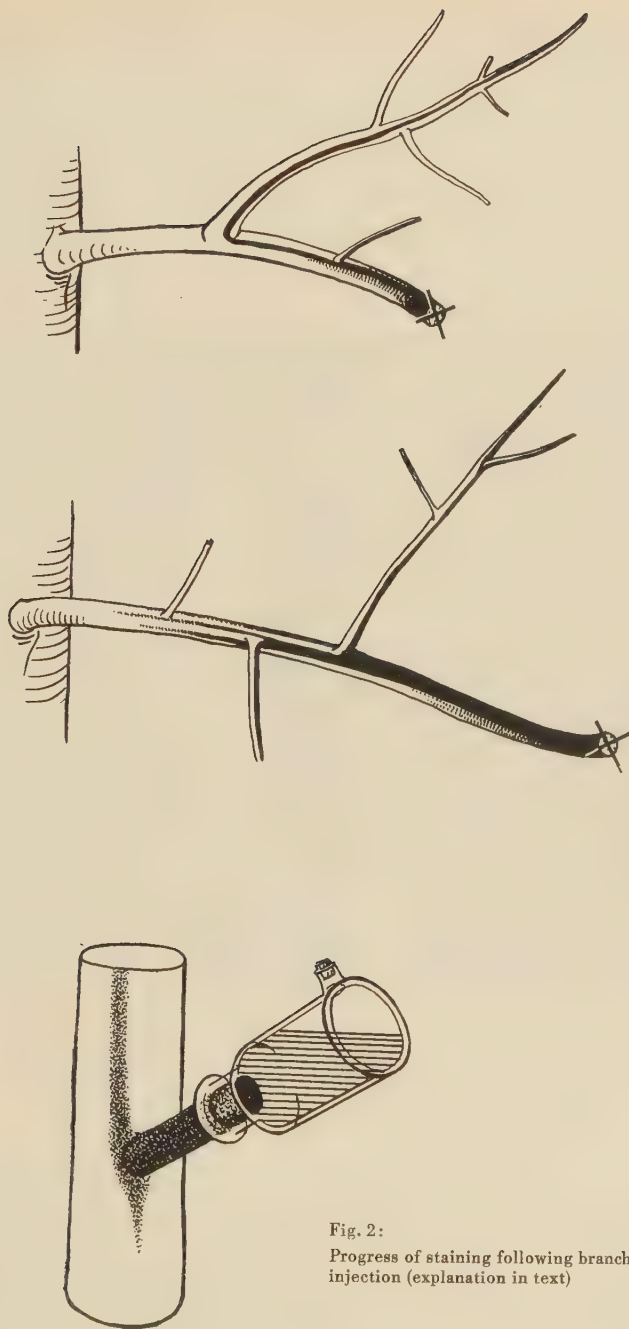


Fig. 2:
Progress of staining following branch
injection (explanation in text)

were used, they were fixed on the trunk at the same height and also placed at fairly equal distances around the circumference. It seemed that 10 to 20 % "Metasystox" was absorbed from the closed vessels only at a gradual rate. The effect produced against the test insect, *Colleophora laricella*, was extremely good, however, and judging from the general situation in the following Spring it was much better than the effect given by the banding method in the same cultures. It is important to note that on the young larches the application of a single cartridge would have sufficed to rid the entire trunk of casebearer larvae. The treated larches remained green and unharmed although they were growing in the middle of seriously infested groups of larches which in Spring, 1956, were completely brown in colour. The same effect was produced when use was made of cartridges with rough, jagged edges, which were hammered into the trunk without removing pieces of bark beforehand. These larches had a much bigger needle foliage all through the Summer.

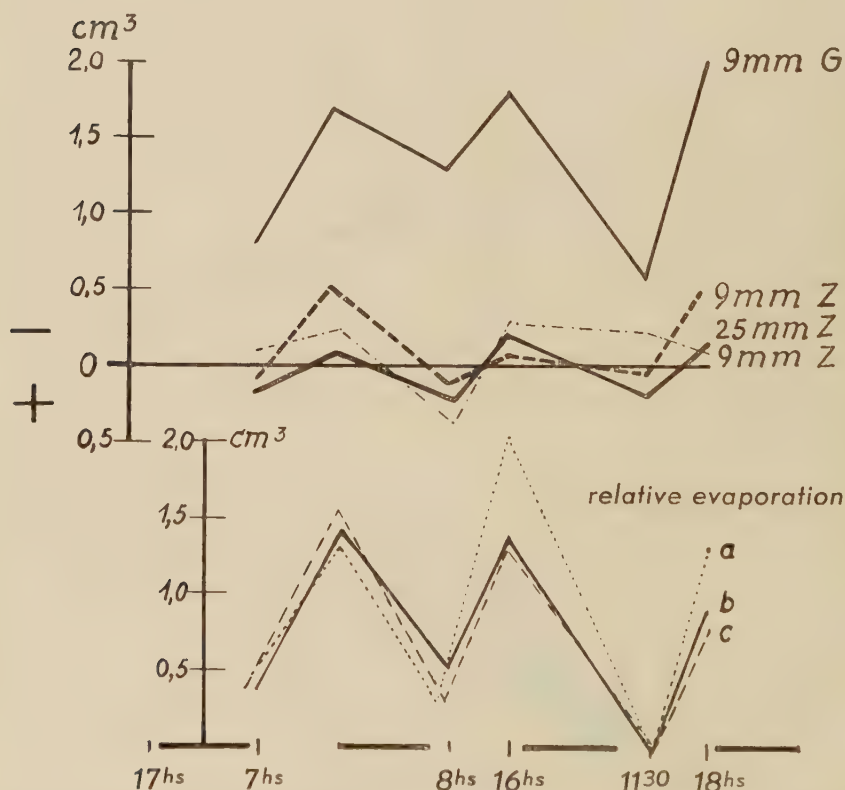


Fig. 3: Process of poison uptake at different times of the day from 9 and 25 mm cartridges of varying shape: z = jagged, g = smooth edge; process of evaporation in lower (a), centre (b) and upper (c) parts of the crown

A number of questions had to be clarified before the method could be modified for practical application. Firstly the process of absorption and distribution, and the influence of the cartridge bore and shape on the incorporation of the poison had to be studied, and an examination made of the effect in relation to the degree of poison uptake (= quantity of poison per unit of time) and the time of application. Corresponding trials were conducted in the Summer of 1956 in various larch cultures and stands in the Forestry Training District, Kattenbühl. Several preparations made available by Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, were used for the applications. Unless otherwise stated, the following information refers, however, to the preparation "Metasystox".

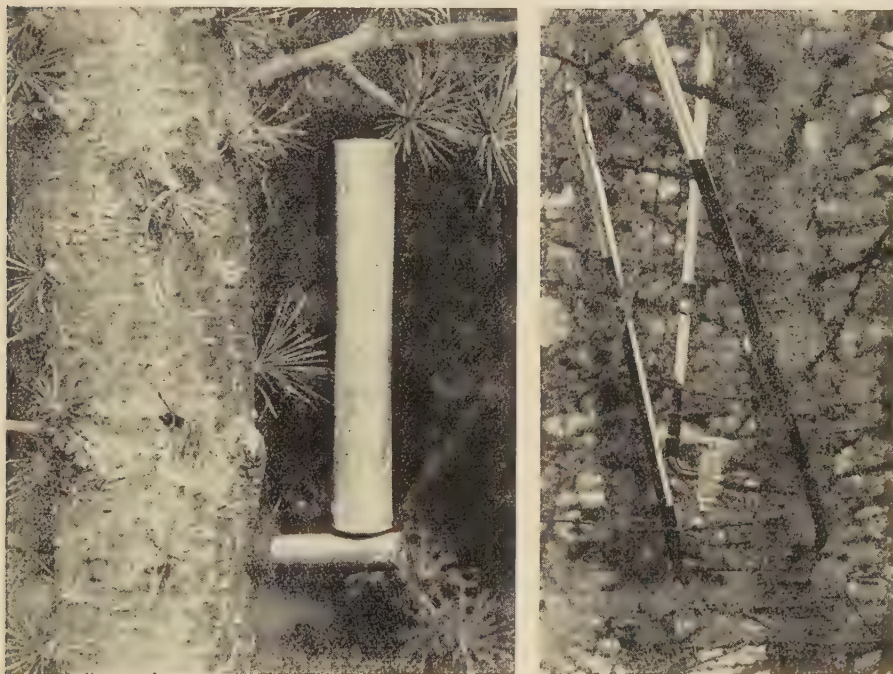


Fig. 4: 9 mm cartridge with open poison container (left), and with mounted burettes to determine uptake of substance from closed vessel systems (right)

Absorption and Distribution

The absorption of 25 % "Metasystox" emulsion takes place in each trunk at different rates depending upon quite a number of factors, in particular the conditions of transpiration flow, which is quite natural, and the suction power. Climatic conditions, time of day, state and relative size of the assimilation surface of the individual trunk and even single parts of the tree lead to fluctuations. On the other hand, a considerable part is played by the cartridge bore, in

particular, however, by the manner in which it is secured in position, the shape of the cartridge edge and the distance from the bark. In the absorption values, however, the rhythm of transpiration at various times of the day can generally be clearly perceived (Fig. 3). The values shown in this illustration were obtained as follows. Closed burettes were mounted on different types of cartridges, and the values shown on the burettes were noted in the morning and evening. The vessel system connected to the transpiration stream was, therefore, sealed. The low pressure formed in the tightly sealed vessels on days when there was considerable transpiration, led to an increase of liquid in the burettes at night-time as compared with a decrease during the day. In the less tight vessels (smooth-edged cartridges which were attached to the xylem after removing bark and cambium), the absorption corresponds to the process of transpiration, as shown by the comparative measurements of evaporation in the lower (a), centre (b) and upper (c) parts of the crown of the test trees, carried out with the aid of Piche evaporimeters.

The degree of absorption with closed vessels (Fig. 4) and without removal of bark, is very slight, and higher when the bark plug blocking the cartridge opening is removed. The approximate values obtained on 12 to 15-year-old larches over a period of five days and recorded in moist, warm July weather, are as follows (expressed in ccs/day):

Cartridge bore mm	Smooth cartridge edge Cambium removed		Jagged cartridge edge hammered in	
	"Metasystox" 25 %	Eosin 1%	"Metasystox" 25 %	Eosin 1%
4	(0.05—0.4) 0.3	—	—	—
6.5	(0.1—0.6) 0.4	—	—	—
9	(2.4—2.6) 2.5	(2.1—2.5)	0.5	0.5
25	(0.9—3.8)	—	0.6	.

With open vessels, the degree of absorption is greater but is subject to most appreciable individual fluctuations. For hammered-in cartridges with 25 mm bore and a favourably shaped edge, the uptake amounts to 4 ccs per day for 25 % "Metasystox", up to 25 ccs per day for 1 % acid fuchsin, and when the bark plug is removed, between 5 and 30 ccs per day of 25 % "Metasystox" may be absorbed.

Regarding the degree of uptake, the values for 1 % aqueous eosin solution are similar to those for 25 % "Metasystox" emulsion. This eosin concentration, however, gives a phytotoxic effect after a short period. Azure-eosin-methylene blue solution and methylene blue solution are absorbed at a much faster rate. Under field conditions, however, the staining effect is slight and these preparations are practically useless. Rapid uptake and good staining with attendant phytotoxic effects were finally obtained with acid fuchsin at concentrations of 1 % and less, in accordance with a recommendation of Roach (1939). There were also several other stains which proved to be inferior to acid fuchsin (cf. Roach, 1939; Schneider-Zimmermann, 1922).

As the degree at which applied substances are absorbed and their rate of translocation depend upon transpiration suction, it would be commendable to have a better knowledge of the dynamics of the transpiration stream in our forest trees, from the aspect of systemic pest control. It is, however, to be expected that conclusions may be drawn from the measurements of the transpiration values and the flow rates of the transpiration stream because these are after all an expression of the suction power. It should be borne in mind that the rise of applied dyestuffs depends upon adsorption at the walls of tracheids, and that for the same reason various substances are translocated at different rates. Under these conditions, a knowledge of the transpiration values and rates in their temporal and spatial variations is of interest for assessing the time for the application of systemic preparations. We are indebted especially to H u b e r (1949, 1953, 1956) and his school for data on transpiration physiology, and in this group it was P l a n k l (1955) in particular who recently dealt with a similar problem, namely by studying the seasonal process of transpiration as a basis for the impregnation of growing forest trees (pine, spruce beech). With regard to the tree species studied, he arrives at the conclusion that the application of chemicals, "to obtain a good and widespread distribution", should be carried out at times when the flow of the sap streams is rapid and persistent because the carrying power, also in capillary systems, increases proportional to the rate of flow. In the Summer of 1954, such periods would have been from the beginning of April to the end of June and from the middle of July until August for pines and spruces.

S c h u b e r t (1939) conducted studies on the transpiration stream of larches. According to his data, the midday maximum rate of flow (measured on the trunk at breast height) is up to 2.44 m/h (according to H u b e r , 1955, up to 1.4 m/h). The rate of flow decreases, however, towards the crown and the root, only to increase again in the direction of the root tip. The transpiration flow comes almost to a standstill at sunrise, while the decrease in the rate of flow is much more gradual. Heavy downpour of rain and sudden temperature drops may have a spontaneous inhibiting effect. From the time aspect, the transpiration stream first becomes active in the branches in the morning, and in the evenings it is also in branches where it first slows down, that is when water is still flowing in the lower parts of the tree. There are also seasonal differences in transpiration (cf. Schubert, 1939, and Plankl, 1955) which are caused by phenological and climatic factors. A factor of special importance for cartridge injection is that apparently differences may develop in the transpiration suction within certain parts of the trunk (Vité and Munzel, 1957).

In order to gain information on the distribution and the rate of distribution of injected substances, a number of staining trials were conducted. For this purpose, use was made only of the two conventional type cartridge cases with a bore of 9 mm (carbine munition) and 25 mm (signal munition) because both the smaller as well as the larger calibre of 4 and 6.5 and 45 mm diameter, respectively, proved to be unsuitable. As the stains are translocated almost solely along the run of the fibres, they are not distributed in the same way as the systemic insecticide. It was, however, assumed that the insecticide is also translocated primarily in the same way, and then distributed to other points. If this assumption is correct, then the poison ought to accumulate firstly in those branches and needles which are supplied direct from the poisoned tracheidal conducting strands.

Correspondingly, the casebearer larvae present in these needles were killed first in relation to other comparable parts. The fact that only branches of about the same thickness and location can be compared, had been established in previous observations which revealed that generally speaking the toxic effect set in earlier and much more strongly in the upper part of the crown and in densely foliated boughs than in lower branches with little foliage.

From this aspect, it is very important to know the run of a fibre section affected by a cartridge injection in order to assess the toxic effect and the rate of effect. It was also possible that indications might have been given regarding selection of the site of application. The corresponding studies conducted by Roach (1939) on fruit trees had revealed that the selection of the site at which a bored-hole injection had been carried out on the trunk, was of the utmost importance for the distribution of the injected substance in the tree. It was most essential on young, thickly-branched apple trees to locate the bored holes so that they were on the border between vascular bundles of two branches. Vascular bundles supplying terminal branches had to be avoided, however, because these appeared to exercise too much suction as compared with other branches.

The staining tests conducted on 8 to 14-year-old larches at first showed the rate of translocation to be 19 to 40 cm per hour in warm, moist summer weather during July. The stain (1 % acid fuchsin) penetrates laterally only 3 mm above the edge of the cartridge both with 9 mm as well as with 25 mm cartridge cases, and rises in the trunk at a width corresponding to the calibre of the cartridge, turning considerably or slightly to the left with slight fluctuations in width until it reaches the top. The radial depth of penetration usually amounts to only a few millimetres, and does not extend beyond the tracheids of the previous year's xylem. The first complete rotation is made by the rising stain streak generally in the lower region of the crown on weak trunks, depending upon the diameter of the trunk and the angle of rotation (Fig. 5), and on sturdy, young larches in the centre part of the crown. Only branches located directly in the stain streak are stained, and old, sturdy branches are stained with a streak which penetrates normally into the terminal shoots of these branches. Of these branches, only those lateral branches running off from the main axis of the stained part are themselves stained in the same manner. Weaker branches or lateral shoots may be completely stained if they are located in the path of the stain streak. Apparently irrespective of the site of application, the stain streak normally reaches the top where it stains, in particular, the base of the lateral branches and shoots more strongly than the uppermost part of the trunk axis: in the previous year's part and the present year's shoots at the top of the trunk axis, the stain is very weak or even invisible, except at the bases of the shoots. All of the present year's shoots branching off from the leading shoot are also stained, in other words practically the whole of the uppermost top section of the tree, furthermore a high percentage of last year's shoots located immediately beneath. Exceptions may be encountered on trees with forks or with (in comparison to the trunk axis) very strong lateral boughs. In such cases, the stained conducting strands may run into one of the forks or lateral branches.

From these tests it may be concluded that the site of application is of secondary importance with regard to the control of thrips because in practically every case the uppermost top section of the tree is well treated with poison. In



Fig. 5:

Course of tracheidal conducting strands on an 8-year-old larch following injection from a 9 mm cartridge

order to examine the same question with respect to the control of *Coleophora*, cartridges of the same type were hammered in at the same height around the circumference of the trunk on a row of larches, and filled with dyestuff. It was found that the absorption of dyestuff was rather uniform on larches with normal crown development. Frequently, however, a stronger absorption was observed on one side of the trunk. These differences, however, were slighter than those which resulted when use was made of different cartridge types inserted in the same arrangement. The location of the site of injection might, therefore, be expected to have a restricted influence upon the outcome of a

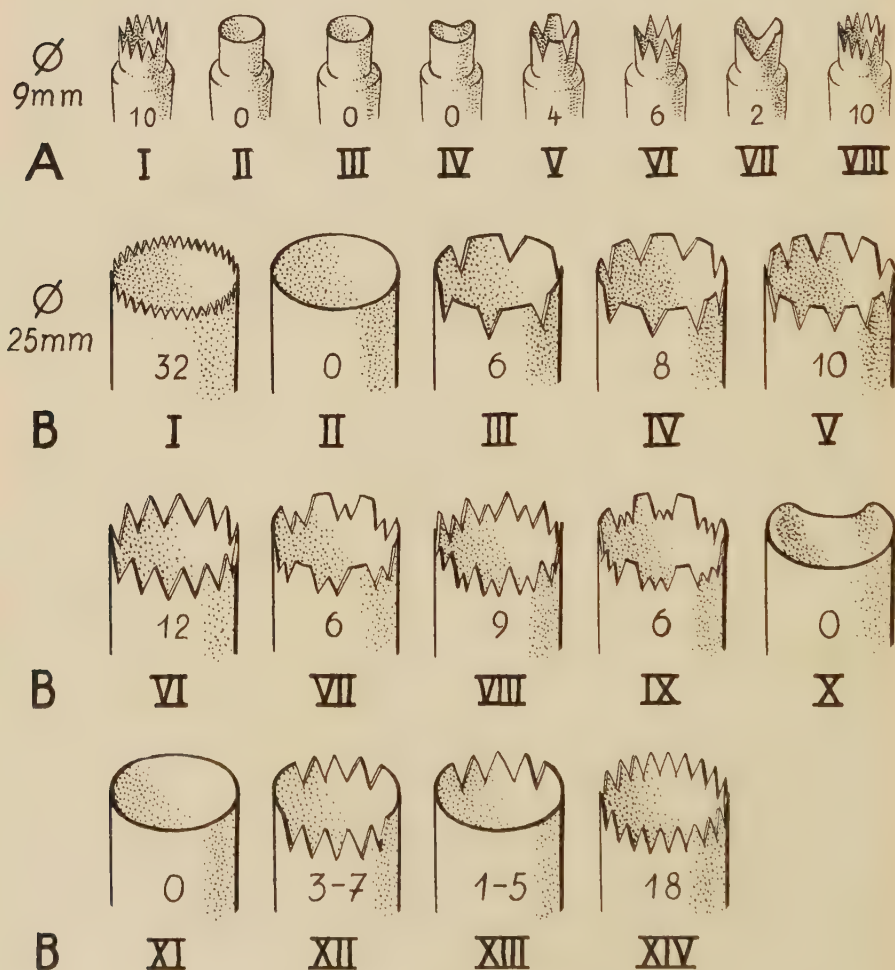


Fig. 6: Rim designs of test cartridges

Coleophora control. In view of the variation in the spiral grain of different larches, however, a locally aimed injection is not possible from the very outset. In other words, it must be left to chance whether the site of application is selected at a favourable or unfavourable part of the trunk. To be on the safe side, the dosage should be adjusted to allow for the unfavourable case.

It is, however, highly probable that in the application of a systemic insecticide, this deficiency can be offset by an apparently existent radial diffusion. In order to make this more clearly understood, a detailed explanation will be given. The systemic insecticide is translocated in the plant chiefly in the transpiration stream, in other words axially (cf Tietz, 1954), although it also penetrates into other tissue and sections; this has already been described as "indirect distribution". Its existence is proved by the fact that the application made at the periphery of the trunk, and at only one section, leads to the eradication of casebearer larvae in the whole of the crown. Hypothetically, this "indirect distribution" can only take place in two ways: 1. peripherally, in other words in the outer xylem layer; 2. radially, by penetrating into the deeper tracheidal layers of the sap-wood which, due to the varying twisting moment of the fibre run, also take over the direct translocation of the insecticide to all parts of the crown. It is obvious from the varying extent of secondary phytotoxic effects, that this "indirect" distribution is a much more inhibited process than the direct translocation of the insecticide. From this it may be concluded that the shorter of the two possible ways, in other words the radial, plays a decisive part in the indirect distribution whereas the peripheral only plays a supplementary part. In view of this, the possibility of an application being made on an "unfavourable" side of the trunk ought, therefore, to be offset since parts of the xylem located radially below the site of injection supply sturdier parts of the assimilation area (cf Vité and Munzel, 1957).

The shape of the cartridge

Once the possibility of carrying out a cartridge injection had been established in principle, it was essential to find a cartridge shape which would be best suited to this method. The cartridges had to satisfy a number of requirements, these being: adequate volume to take the poison, optimum diameter of opening, capable of being driven into the bark, adequate sealing off, and good adherence to the trunk. For reasons of economy, it was decided to use conventional types such as the 9 mm brass case of carbine ammunition with a maximum volume of 6 ccs, and the 25 mm aluminium cases of signal ammunition with a maximum volume of 39 ccs. An attempt was made to render them serviceable for the injections by modifying them in as uncomplicated a manner as possible. This succeeded although with the disadvantage that the volume of the 9 mm was too small, and the opening of the 25 mm cartridge was unnecessarily large, at least for trees of the 1st age class.

The tests had shown that the "ideal" cartridge type should consist of a case with an opening diameter of approximately 15 mm and a volume of 30 to 50 ccs. As a provisional measure, a cartridge satisfying these requirements in principle was made in the following manner. A 9 mm cartridge was fitted with a tin foil tube having a volume of 25 to 40 ccs by making a bore in the centre

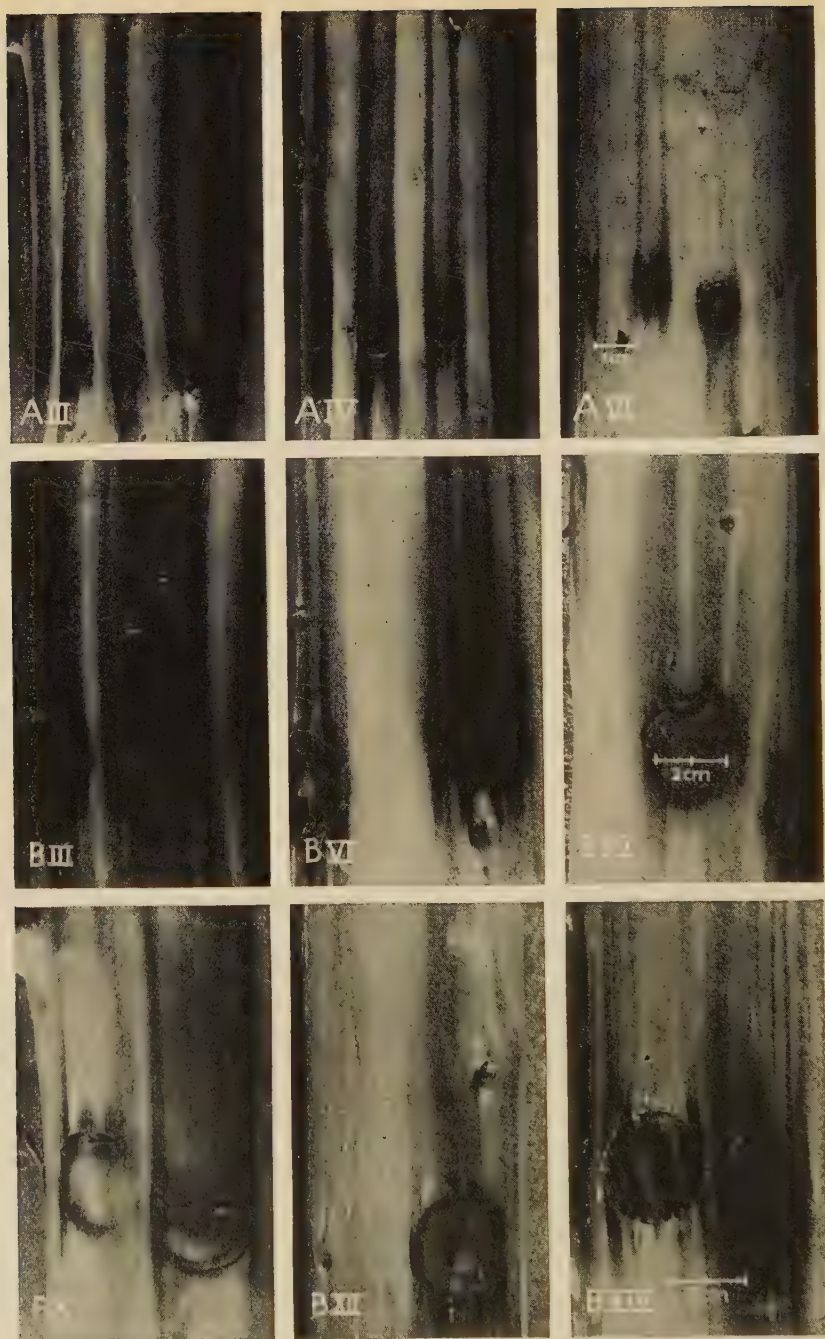


Fig. 7: Influence of the shape of the cartridge rim on the flow of dyestuffs into the xylem

1. Bark and cambium removed from the cartridge bore:

A. 9 mm brass case		B. 25 mm aluminium case	
Rim shape:	Staining:	Rim shape:	Staining:
I. Finely serrated edge (10 teeth)	Intensive, broad and deep	I. Finely serrated edge (22 teeth)	Intensive, broad and good depth effect
II. Smooth	Intensive, broad	II. Smooth	Intensive, broad

2. Bark not removed, cartridge driven in direct:

III. Smooth	Intensive*, broad (Fig.)	III. Roughly subdivided (6 notches)	Intensive, broad seldom streaky (Fig.)
IV. Depressed	Intensive*, 2 streaks (Fig.)	IV. Roughly subdivided (8 notches)	Intensive, often streaky
V. Roughly subdivided (4 notches)	Weak, streaky	V. Roughly subdivided (9—11 notches)	Intensive streaky
VI. Deeply serrated (6 teeth)	Weak*, streaky (Fig.)	VI. Deeply serrated (12 teeth)	Moderate to intensive, streaky (Fig.)
VII. 2 side serrations	Weak, 2 streaks	VII. Roughly subdivided with spacing	Moderate, coarse streaks (Fig.)
VIII. Finely serrated (10 teeth)	Weak**, uncertain	VIII. Roughly subdivided with 2 spaces	Moderate, very coarse streaks
		IX. Deeply serrated with spacing	Moderate, streaky
		X. Depressed	Moderate and uncertain** (Fig.)
		XI. Smooth	Moderate and uncertain**
		XII. Rough combinations (3—7 teeth)	Moderate, streaky (Fig.)
		XIII. Rough, one-sided combinations (1—5 teeth)	Moderate, streaky
		XIV. Finely serrated (18 teeth)	Weak, streaky (Fig.)

*) Fails occasionally } due to tight
 **) Fails frequently } sealing of cartridge
 orifice

of the case. The case can be shortened by cutting off the front third-section, and the bore also widened to 10.5 mm (Fig. 4).

A factor of great importance for the uptake of the injected substance proved to be the shape of the cartridge rim, and also whether the bark plug should be removed or left in. This plug is formed when the cartridge is driven into the trunk, and more or less blocks the opening of the cartridge. There are certain differences depending upon the size of the cartridge and the material. The assessment of the suitability of various rim shapes was made once again by means of staining tests. The intensity and the continuity of the rising stain streak were taken as standards. As deep staining nearly always resulted immediately above and below the cartridge, the further course of the stain streak also had to be examined. The different rim designs are grouped according to the intensity of staining in the preceding table, and in Figs. 6 and 7.

The deepest and surest stainings were obtained when the bark plug was removed. In this case the shape of the cartridge rim was of secondary importance. Small serrations on the rim are an advantage in that the stain penetrates somewhat farther into the trunk, and they enable the cartridge to be secured more firmly to the trunk.

A difference of significance, however, is when the cartridge with a smooth rim is driven into the bark, irrespective of whether the rim is circular or depressed at one side. Whereas deep stainings are obtained with the 9 mm cartridges — although involving a certain instability factor — the stainings produced with the 25 mm cartridge are usually only very weak, whereby the depressed rim is somewhat superior to the round cartridge rim. Occasional exceptions where deeper stainings were produced only serve to confirm the general rule just as, on the other hand, weak stainings were obtained several times with the 9 mm case.

The rims with two serrations, the finely serrated rims and the combination shapes were found to produce weak stainings. With these rims, uncertain staining results as a rule only on both sides of the stronger teeth and at the edges.

Strong, evenly pointed teeth on the 25 mm cartridge lead to certain staining which is mostly deeper and streaky. In fact the staining is deeper with such teeth when they bend on being driven in. A similar effect is produced at the edges of the stain streak when the same fibre sections are struck by several teeth. When the bark plug is not removed, the most reliable staining is produced with the same case when it is provided with a roughly sub-divided rim. The edges of the protruding parts bend when driven in, and thus produce cavities for the stain to flow in, and stronger superficial contact points with the xylem.

Because of the secondary effects, a streak-wise overflow of the insecticide is preferable — this of course must also be adequate in quantity — and therefore for injections with the 25 mm cartridge, suitable rim designs are those marked B. V. and VI. in the illustration. Due to the small diameter of the opening, the only rim shape suitable for practical purposes when 9 mm cartridges are used, is the A. I. design, with the bark plug removed beforehand.

A problem associated with all shapes of cartridge rims, however, is to obtain a sufficiently tight contact with the bark. A part of the liquid in the cartridge usually trickles out and runs down the trunk when the filler hole at the rim of the case is not plugged with a cork. This is particularly the case with cartridge

rims having a rough serration and with the 25 mm cartridge. Good sealing can be obtained with the 9 mm cartridge by drawing a narrow piece of rubber hose over the neck of the cartridge before it is driven into the bark (cf. Fig. 4). Furthermore, a single layer of insulating tape wound around the case 2 to 3 mm below the outer rims generally gives an effective makeshift sealing for the 25 mm cartridge. Cartridges on which the filler hole is plugged, lose hardly any liquid, although the overflow of the solution into the trunk is considerably delayed as a result.

The effect of the cartridge injection

Even at low rates of application and with short periods of injection, the cartridge injection method gives a very good effect against larch thrips. The supply of the tree top with the injection poison, already described, and the fact revealed by the application of the banding method that the strongest parts of the assimilation area — in other words the periphery fully exposed to the benefits of light — absorb injected substances most, are of the utmost importance for the control of thrips. The sites at which the poison accumulates most conform practically in the same order with the colonization potential of the thrips which can only satisfy its food requirements on new, sturdy shoots, and usually colonizes the terminal shoots of the upper crown region.

The best time for carrying out an application again proved to be from the end of June until the beginning of July. However, relatively little can yet be said about the rates of application because only a few 12 to 14-year-old larches were treated, and injuries by thrips were prevented on all of them. On the other hand, very serious damage by thrips was inflicted on untreated larches in the same culture. The treatment was carried out on June 26, 1956, and the period of the application varied between 6 and 50 days when 9 mm cartridges were used with 25 % "Metasystox" applied in a quantity of 10 to 25 ccs. The 25 mm cartridges remained on the trees for 4 to 14 days, and used up quantities of between 5 ccs and 20 ccs of 25 % "Metasystox". The quantity of pure active substance applied therefore, amounted to only 1.5 to 7.5 ccs. In fact, in extreme cases, only 3 ccs of 5 % "Metasystox" were absorbed over a period of 20 hours but also led to a good effect being produced against *Taeniothrips*. These figures should, however, be treated with discretion because the insecticide was applied from graduated glass vessels which held a rather large quantity, and it is quite probable that the emulsion did not remain in a homogeneous physical state particularly when used over long periods.

In contrast, the effect against the casebearer was less rapid and not fully satisfactory. Large dosages, however, acted relatively fast. Following an application of 30 ccs of 100 % "Metasystox" in a 25 mm cartridge on a 9 metre high, 13-year-old larch, the *Chermesidae* were all killed after three days had elapsed, no more *Taeniothrips* larvae were to be seen, and egg larvae of *Coleophora* hatching out during the next few weeks died while they were boring into the bark or shortly afterwards. On other larches, described above, the effect of 25 % "Metasystox", using cartridges of different types, varied against casebearer larvae and was in fact slower.

Finally, it should be mentioned that the treatment with "Metasystox" on young, isolated larches also produced an effect on the branches below the site of application. It is not clear how this came about, from the phytophysiological aspect.

Secondary effects

A disadvantage of the cartridge injection is the unavoidable injury to the cambium. Although the injury caused to the trunk has no other after-effects either technically or physiologically except perhaps for the healing over of a branch wound, that is provided the injection is carried out properly and efficiently, the psychological reaction to the unpleasantness of the operation may alone serve to deter one from applying the method. For this reason, the extent of the injuries was given close examination.

The injury consists firstly of a purely mechanical severance of the cambium, amounting to the size of the cartridge bore. An attempt was made to prevent this part from perishing by using cartridges with certain rim shapes (A VII;

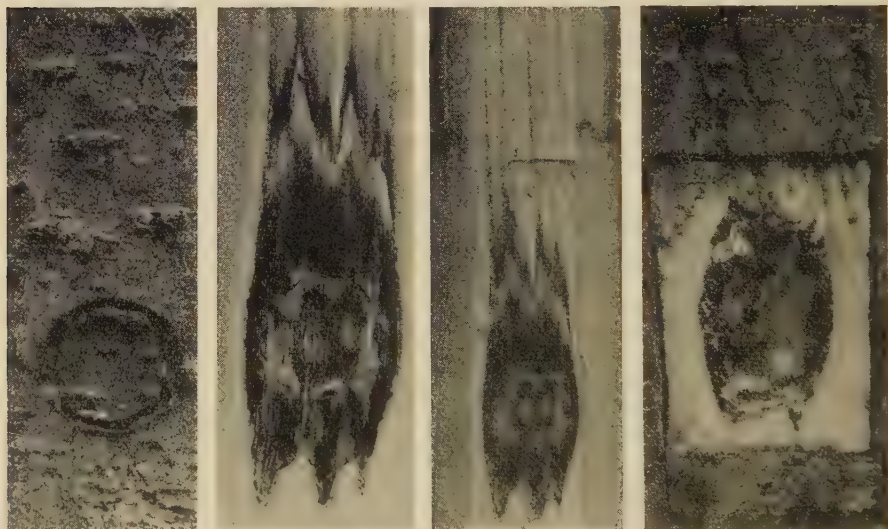


Fig. 8: Site of 25 mm cartridge injection three weeks after removal of cartridge: outer view (left): necrotic zone and commencement of healing-over under the bark (1st from left); view following removal of bark, showing xylem which meanwhile has grown together (2nd from left). Comparison: normal healing process of a purely mechanical wound

B VI—VIII). Practically speaking, however, this cannot be done, because in addition, a restricted phytotoxic effect is exerted by the insecticide on those tissue parts directly affected, which makes it completely impossible to save the part of the cambium severed by the cartridge by using certain rim designs as attempted. The phytotoxic effect did not set in until 6 to 10 days had elapsed even at a "Metasystox" concentration of 100 % but lower strengths of between 10 and 20 % also had the same effect. It is to be attributed to the otherwise very high order of plant tolerance of the preparation that the toxic effect remains strongly localised. The lateral expansion of the dead tissue from the rim of the case amounts to only 2.2 mm for the 9 mm cartridge, and 5 mm for the 25 mm cartridge. The vertical expansion varies, being always greater in an upward

direction than it is in the opposite direction although it only amounts to a few centimetres in both cases. The directly hit tracheidal conducting strands, too, turn brown over a length of 50 to 60 cm, although these discoloured parts are only a few millimetres or fractions of a millimetre wide (Fig. 8). In the centre of the cartridge opening, necrotic discoloration penetrates only 0.7 mm into the xylem. The healing-over process normally starts at the side edges of the wound, and progresses all the more rapidly the farther the edge is away from the

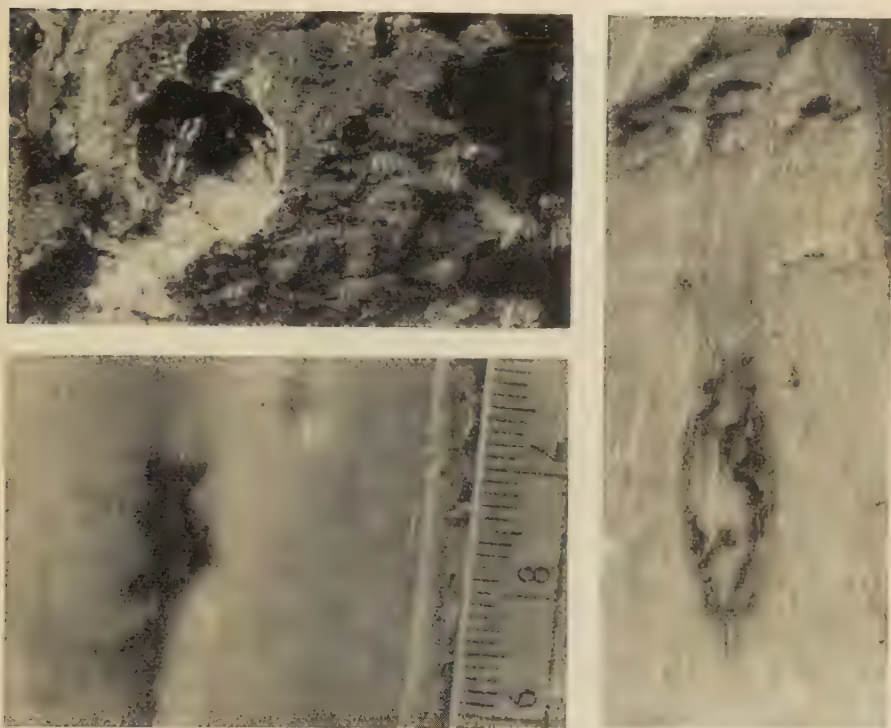


Fig. 9: Site of injection healed over, one year after injection with a 9 mm cartridge. Right: Original extent of necrotic zone exposed following removal of wood which in the meantime has grown together (scale in cm)

cartridge opening. Particularly the dead parts above the opening become healed over within a few weeks, whereas the callus tissue of the wound edges level with the cartridge opening, only heals over a slow rate. The peripheral swelling of these parts continues to display symptoms of toxicity for some time, due to the persistent phytotoxic potency of the injection point.

In contrast, a purely mechanical wound made by way of comparison healed over in the normal way. In its width, the wound remained restricted to

its original dimension, and the upward and downward expansion was very slight. The formation of callus progressed at the fastest rate on the sides, less quickly at the upper edge, and was slowest at the lower edge, just as established for the healing process of wounds on boughs (Mayer - Wegelin, 1936).

With 9 mm cartridges for which the entire width of the necrotic region only amounts to 14.5 mm, the healing-over process is completed in one year (Fig. 9). The cartridge injection is, in other respects, just as harmless as green-pruning, and on healthy trees the danger of fungal infections developing from



Fig. 10: Fungicidal effect (outlined) of "Metasystox" in immediate vicinity of injection site (A); the remainder of the trunk was completely covered with mould fungi four weeks after the application and three weeks after removal of the bark

the wound is slight from the very outset. This danger is eliminated in that the insecticide used, at such a concentrated action, possesses a fungicidal effect (Fig. 10), added to which the wound surface becomes completely resinous immediately after the liquid is absorbed. In order to counteract the possibility of a technical injury, the cartridge could be applied at the foot of the trunk. At all events, the cartridges should not be left affixed to the trunk for more than a week otherwise the extent of phytotoxic injuries, particularly below the cartridge, might be increased appreciably.

Mention should also be made of another possible secondary effect. According to the studies of Bhattacharyya and Linskens (1955), there is a certain danger that "Metasystox" may have an influence upon the cell nuclei and chromosomes, even when this preparation is applied at relatively weak concentrations but direct. In these studies, the test plant used was *Vicia faba*, on which disturbances of the maturing division in the pollen mother cells and embryos of the flower buds were caused, in particular. This would raise some doubt as to the suitability of this method for application perhaps in seed plantations.

The Knife Injection

In addition to the banding method and the cartridge injection, an attempt was made to inject larches by means of "injection needles" such as are used in wood preservation in the so-called "Cobra injection method" for the depth impregnation and aftertreatment of masts (Mahlke - Troschel - Liese, 1950; Dölger, 1954). It was very soon discovered, however, that these needles are much too large and that their construction is unsuitable for our purpose, furthermore that the hand equipment normally used for inserting the needles is superfluous (cf Dölger, 1954, and "Impraegna" System cited after Plankl, 1955). In fact it was found to be quite adequate merely to drive a simple type, leaf-shaped hollow knife fitted with a short edge into the sapwood, and to mount a poison container on the handle of the knife. When a clamp with a rubber seal is fitted at the end of the handle, the injection liquid is prevented from flowing out of the injection slit (see Fig. 11 for construction). Tin foil tubes which can be screwed on, were again selected as containers.

In its effect, this type of injection may be rated between the banding method and the cartridge injection. Damage to the tree is restricted to a minimum; technically, damage is negligible because the knife hardly injures the wood structure and only holds it apart so that the injection slit closes again as soon as the knife has been withdrawn. As the poison merely comes into contact with a narrow strip of cambium and the translocation of the poison is shifted radially into the depth of the sapwood, the phytotoxic effect is also very limited. The absorption and distribution of the substance in this method proved to be unexpectedly intensive. The injected substances were not only absorbed very quickly but also translocated over wide parts of the crown. It was an easy matter to trace this direct translocation by means of staining. A narrow streak of stain rises up the trunk on the xylem surface along the run of the fibres, making a typical left-hand turn. Radially, this streak penetrates to a depth equal to the distance which the injection knife is driven in, or in other words, equal to the extent to which the sapwood splits. The radial streak, however, only runs parallel to the peripheral band for a short period. Conforming to the run of

fibres in the different layers, the radial staining shifts as the axial distance from the site of injection increases, and soon runs in a curve to the heartwood, later describes a completely open arc, and finally becomes visible as a spiral arc (Fig. 12a). The completion of the first spiral arc depends upon the degree of turn in the fibre run and the thickness of the tree. Accordingly, most of the lateral boughs and the whole of the tree top are supplied direct with the substance injected.

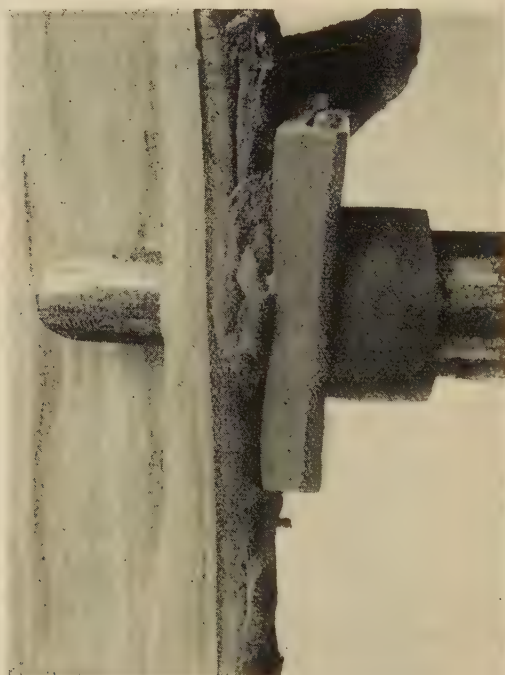


Fig. 11: Instrument used for knife injections

The knife injection therefore combines the advantages of the banding method, namely direct distribution on a wide basis, with those of the cartridge injection which gives good supply to the top region of the tree. Consequently, it is most suitable for the joint control of casebearers and thrips. Further details on rates of application and the success of the method cannot yet be given, however, because only a few knives have been made so that it has only been possible to carry out individual trials. With a view to cutting the expense incurred for making the injection knife, tests were conducted in which 9 mm cartridges with poison containers mounted on them, were located in holes bored into the sapwood. It was found, however, that the injection given by

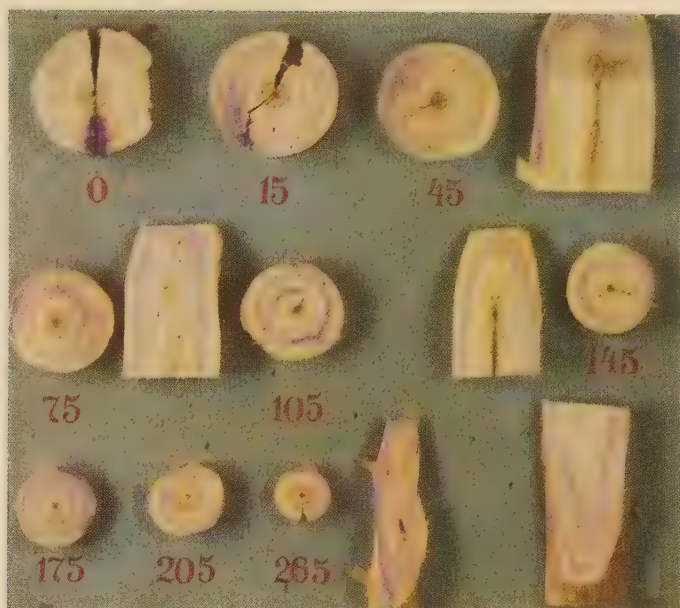


Fig. 12a: Distribution of stain applied to an 8-year-old larch by means of knife injection method

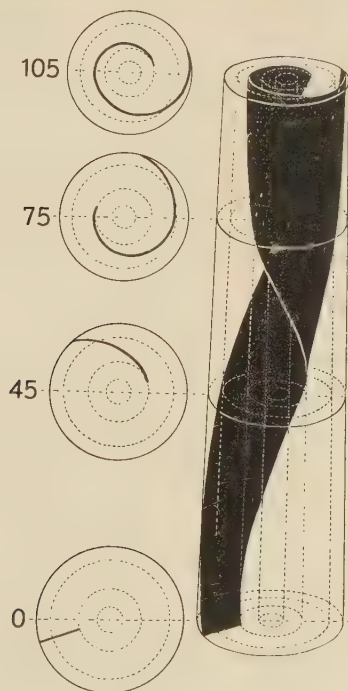


Fig. 12b:

Illustration showing the path of translocation of the stain injected into the sapwood of the same larch. The figures indicate the height of the cross-section in cm above the injection site (0) and correspond to the stem section shown in Fig. 12a.

this method was unsatisfactory, and by no means comparable with the knife injection. Practically speaking, this method could not be given consideration due to the work involved, and injuries caused to the tree.

The Economic Aspect of the Methods

All three methods are still by no means ready for practical application yet nevertheless it would appear advisable in the interests of developing them further, especially with a view to conducting larger trials, to give consideration to the technical and economic aspects.

This very rough comparison of costs is based on the assumption that only half of the banding material can be used again, because practically speaking the cellulose cannot be considered for re-use. Should it be intended to repeat the treatment of the larches in two successive years, the band could be left on the trunk. This procedure, however, cannot be favourably assessed due to the secondary effect on the trunk and a degree of uncertainty as to the effect produced based on a change in the condition of the cellulose and its suction power after one year, which is difficult to estimate. On the other hand, the service life of an injection could be estimated at being greater than 20 applications.

Apart from a wire brush and a device to remove the bark scales, no special tools are needed for the banding method. Due to the unavoidable amount of work involved in the complicated process of binding up the trunk, cutting the Igelit and fastening the band, a two-man team has to be employed. Experience gained in Switzerland has shown that when the process of banding is done very thoroughly and efficiently, a team of two (women) can treat 8 to 12 larches per team working hour (Martignoni and Zemp, 1956). The author has experienced that with a certain degree of skill and good preparation, 15 trees can be properly treated per team working hour.

A big technical disadvantage of the banding method is that the operators are greatly exposed to the penetrant odour of the preparation used, and that they have to wear rubber gloves when carrying out the treatment. This is a great hindrance at least in a part of the process. For carrying out cartridge and knife injections, it is advisable to use a few simple tools. When using old 25 mm cartridges which can easily be purchased as scrap, it is commendable to make the triangular notches in the rim of the cartridge with a pair of punch pliers like those used for punched card index systems. The filler hole at the rim of the cartridge is best done as a makeshift measure by simply punching it with a round chisel, placing the cartridge on a wooden shaft. These tasks are very easy to complete. 150 cartridges can be prepared in one working hour. The makeshift preparation of 9 mm cartridges fitted with poison containers is a different proposition, and cannot be done on a sound economical basis. The material is harder, and it is difficult to make a tight joint between the cartridge and the container. The same applies to the injection knife.

The use of a light hatchet is most commendable because it is then not necessary to change the tool, and it can be used both for smoothing the bark as well as for firmly driving in the cartridge or knife. For the same task, use was made of a tool fitted on the one side with a hammer, and on the other side with a hook-like drawknife that has a wide flat blade (Fig. 13). This tool is not available on the market. An advantage of using this tool is that injuries to

A. Banding method	Cartridge injection		Knife injection
	B. 9 mm cartridge	C. 25 mm cartridge	
1. <i>Costs of material:</i> Igelitt cellulose, bast fibre (per treatment of one larch of 15 cm diameter = DM 0.22)	DM 0.50 (with container and seal)	DM 0.20 (in blank form; scrap price) approx. DM 0.40 when finished	DM 5.— for making single knives with container fitted
2. <i>Re-usability:</i> Durability of material is very restricted and can only be used again in certain cases	Unrestricted	Restricted	Unrestricted
3. <i>Preparations:</i> Cutting Igelitt foils into strips 20 cm wide, splitting up cellulose DM 0.01	None	Punching cartridges. Covering with a layer of insulating tape DM 0.02	None
4. <i>Application:</i> Cleaning or reddening of trunk bark with wire brush to give a 20 cm ring Wrapping with 10 cm wide layer of cellulose. 20 cm wide strip of Igelitt, and tying up at bottom end with bast Pouring in emulsion (rubber gloves!) Tying up top edge and folding over top seam (to prevent accumulation of drip water) DM 0.20	Withdrawal of bark plug Driving in cartridge Filling up container DM 0.04	Smoothing bark with hatchet, preferably with draw-knife Driving in cartridge Filling up cartridge DM 0.04	Smoothing bark Driving in knife Filling up container DM 0.04
5. <i>Removal:</i> Cutting open bast fibre, scraping off cellulose, destroying unusable material DM 0.05	Withdrawing cartridge DM 0.01	Withdrawing cartridge DM 0.01	Withdrawing knife DM 0.02
Labour costs per unit (based on wage of 1.50 DM per hour)			
DM 0.26	DM 0.05	DM 0.07	DM 0.06
Based on 20 repeat applications, costs of material per application would be:			
DM 0.11	DM 0.03	DM 0.02	DM 0.25
DM 0.37	DM 0.08	DM 0.09	DM 0.31

the bast can be avoided better than with a hatchet. To remove the bark plug, which is necessary in order to insert 9 mm cartridges, use should simply be made of a similar cartridge or, better still, a corkscrew with a slightly smaller cross-section. The bark plug can be cut out quite easily with both tools. The cartridges or knife can be carried in a bag slung over the shoulder, like those used by cone pickers. The emulsion can be transported in well-stoppered containers which can be shut off quickly. In the tests it was found that plastic bottles (polyvinyl chloride bottles) are extremely suitable. They were fitted with bent tube with a narrow opening, inserted through the stopper. When containers of this type are used, it is not necessary to wear rubber gloves.



Fig. 13: 25 mm cartridge; driving the cartridge into the trunk by means of a special hammer

Even though a two-man team is not essential for carrying out cartridge or knife injections, it is nevertheless an advantage to have two persons to do the work because just as much time is taken locating the trees and applying the apparatus as filling up the containers with poison and fetching fresh supplies. One man can apply 40 injecting devices per hour in a 20-year-old mixed stand of larches and beech trees containing 30 % larches, whereas two men can treat more than twice as many trees in the same time.

The re-use of 25 mm cartridges is limited only insofar as the efficacy of these cartridges depends upon the rim teeth becoming bent which happens very often when they are made of soft material. It is, therefore, necessary to readjust them each time they are used, and cartridges which are badly bent should be

replaced by new ones. On the other hand, the injecting knife and 9 mm cartridges can be re-used for practically unlimited periods. This also has another advantage. It is not necessary to leave these devices in the tree any longer than one week to ensure an effective injection (probably only a few days), and therefore they can be transferred to other trees at the end of this period. In fact, with careful planning, the removal of the device and its insertion in the next tree can be combined in one operation, with the result that far fewer devices are required for the treatment.

When comparing the costs incurred for the different methods, it appeared advisable not to include the costs of the poison or to make allowance for water requirements because after all only small quantities are needed. Assuming 400 larches per hectare have to be treated in one stand, approximately 100 to 150 litres of water are needed per hectare for the banding method, and only 4 to 8 litres per hectare for the cartridge or knife injection.

At present, however, the application of these methods on a large scale — in addition to the fact that they have not yet been adequately tested — is opposed by the high price of systemic insecticides available on the market, and fairly large quantities of poison are needed. One point is clear, however, namely that the banding method, which involves a fair amount of work, is inferior to the cartridge and knife injections both in implementation and in its effect. Of the latter methods, preference should be given to the cartridge injection for controlling thrips. Moreover, considering that less harm is caused to the trees, the 9 mm cartridge fitted with container should be used particularly for the treatment of young larches. The knife injection, on the other hand, gives promise of better results when casebearers and thrips have to be controlled jointly.

Injections can only be carried out on an economical basis in mixed stands where the possibility exists of combining the treatment with a selection of trees. The pruning of these trees could also be included in this joint process. Treatments of large areas should be given preference where it is a case of controlling casebearers in pure stands or where mixed stands have to be treated which contain a high percentage of larches. The method of dusting in August suggested by Thalenhorst (1953), which has already been tested on a wide scale, gives very satisfactory results and incurs far lower costs that would ever be possible with individual treatments.

Summary

1. The known possibilities of injecting growing trees against insects, and the aims and applicability of these methods are discussed briefly; the formulation of the problem is based on the need for evolving a practical method for carrying out a joint control of two troublesome larch pests, *Taeniothrips laricivorus* Krat. and *Coleophora laricella* Hb.
2. Details are given of the development, implementation and control results of three methods:
 - a) The "banding method"; the uninjured trunk is bound up with a layer of cellulose, the width of a hand, soaked in insecticide.
 - b) The "cartridge injection"; a cylindrical container with an opening of 9 or 25 mm diameter, is placed against the outer xylem.

- c) The "knife injection"; a small hollow knife is driven through the bark into the sapwood parallel to the run of the fibres.
3. The methods are effective against both pest species but their successful application is greatly restricted temporally (end of June to beginning of July). The effect which sets in somewhat later, must give control of the egg larvae of the pests; the translocation and distribution of the poison is adequate at this time because the needles are still intact and assimilate strongly.
 4. In the banding method, relatively weak concentrations of poison are inclined to be more effective against casebearers than against thrips, whereas stronger concentrations give control of both species; on the other hand, cartridge injections of weaker concentrations are more effective against thrips, while stronger dosages give control of both species throughout the whole of the crown.
 5. The toxic effect also extends to parts of the crown below the site of application although it varies depending upon the suction power of the different branches, particularly when weak dosages are applied.
 6. The banding method does not cause any secondary effects right up to the end of the vegetation period provided the band is removed in good time; if not, slight bulges may form on the bandaged parts of the trunk. The cartridge injection causes, in addition to the insignificant mechanical injury of the cambium, local phytotoxic effects around the site where the cartridge is inserted; these can be reduced by removing the cartridges in good time (within one week).
 7. From the labour aspect and with regard to efficacy, cartridge and knife injections are superior to the banding method.
 8. Peculiarities of the treated tree species (one-year foliage generation, high transpiration output) and the pests render possible the successful application of these methods. It would be wrong to conclude from this that the same methods could be applied with success on other tree species and against other pests.

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The Possibilities of Control of Jute Semi-looper

(*Anomis sabulifera* Guen.) by "Folidol-E 605"

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Jute is one of the major agricultural produce of India. Jute of commerce is the fibre extracted from the bark of the plants *Corchorus capsularis* L. and *Corchorus olitorius* L. (Tiliaceae). It is a monsoon crop and the plants are raised from seeds. ~~Seeds are usually sown during March-April and the crop becomes ready for harvest in September-October.~~ The harvested crop is steeped in water for some time and ultimately the fibre is extracted.

The crop is attacked by a number of insect pests, of which the Semi-looper, *Anomis sabulifera* Guen. (Noctuidae — Lepidoptera), is one of the most important. The Semi-looper has been a universal pest in all the jute growing tracts of India. The pest usually appears from the last week of June to the first week of July. The moths lay eggs on the leaves, usually on the under-surfaces in a scattered fashion. ~~The caterpillars come out within 2-3 days and pass through 3 moults and pupate inside the soil.~~ The total life-cycle from egg to adult occupies 20-30 days. There are usually 3-4 generations in a season of which the second one is most destructive to the crop. The life period and the number of generations depend on climatological factors and vary from place to place.

Damage to the crop is caused as the caterpillars feed on the leaves and growing apex of the plant. The normal growth of the plant becomes stunted and new apex comes out behind the original one; this reflects ultimately on the final yield as a result of shortening of fibre-length, often deteriorating the quality of the same. Jute crop which is sown late in the season is subjected to more severe attack by the insect than the crop raised in time (Dutt, 1952).

Various methods of control have been tried to combat the pest. Hand-picking of the caterpillars, installing light traps in the flight season of the moth, collection of crysalids from the soil underneath the crop, have been practised; but these methods have served at the best, only to check the spread of the insect to a small extent. Chemical measures of control have also been tried and found to be widely appealing. Jute is a rainy season crop and control of the pest with chemicals poses rather a difficult problem. DDT and BHC are the two synthetic hydrocarbons which are commonly used against the Semi-loopers either in wettable or dust formulations. Both the insecticides are efficient in their correct dosages against the Semi-loopers when they are kept in the insecticidal field long enough to obtain a lethal dose. But in the field condition the insecticidal deposits are often washed off or drifted away by rains or high wind actions. Therefore, the time required to obtain a quick kill is of much practical importance.

The possibilities of "Folidol-E 605" (diethyl paranitrophenyl thiophosphate 46.7 %, the rest special emulsifier) an organophosphorous compound manufactured by Messrs. Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, with a

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vast range of insecticidal properties on a great variety of insects and with a special penetrating power into the plant tissues — to bring quick mortality of the caterpillars have been explored and the results of the findings are presented in this paper.

Tests were carried in the laboratory in petri-dishes with 5 different concentrations of "Folidol-E 605" * (.004 %, .013 %, .018 %, .023 % and .027 %) and 3 different concentrations * (.25 %, .5 % and .75 %) of DDT 50 % W.P. to make

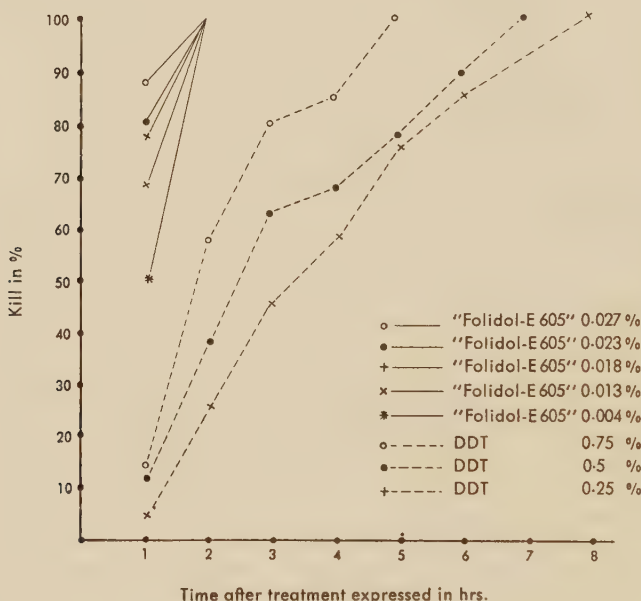


Fig. 1: The effects of different concentrations of "Folidol-E 605" and DDT 50 % W.P. on Jute Semi-looper *Anomis sabulifera* Guen.

a comparative study of the two insecticides. Third and fourth instar caterpillars were used as test materials which were reared from eggs laid in the laboratory. There were four replications per treatment, each replicate with 10 caterpillars. Diameter of the petri-dishes was 12.5 cm and each received a spray of $88 \pm .04$ cc by volume. Spraying was done by means of an atomizer. Observations on the mortality of the test caterpillars were made at regular hourly intervals and the results are shown graphically in Figure 1.

* In terms of actual insecticidal ingredient.

It may be seen from the above graph that "Folidol-E 605" at all dosage levels can effect 100 % mortality within 2 hours of application under the laboratory conditions. DDT 50 % W. P. at its highest dosage level (i. e. .75 %) could produce 57.5 % mortality of the test caterpillars within the same period while the other two dosages of DDT, i. e. .5 % and .25 % gave only 37.5 % and 25 % kill, respectively. For obtaining complete kill of the test caterpillars .75 % DDT took 5 hours, .5 % 7 hours and .25 % 8 hours.

The performance of the lowest dosage strength of "Folidol-E 605" is better than the highest dosage strength of DDT under the laboratory conditions and the cost of the insecticide required per acre with the above dosage rate is lower than that of DDT. There is some amount of scepticism in certain quarters with regard to field application of "Folidol-E 605" as it is an organo-phosphorous compound and may result in application hazards to those who handle it. A preparation based on diethyl-p-nitrophenylthiophosphate, in form of a concentrate, has to be handled with care by observing the prescribed precautionary measures. In "Folidol-E 605" the hazard of skin toxicity being of great importance under field conditions, has been eliminated up to $\frac{1}{7}$ th part of the pure product by the use of a suitable emulsifier.

As such it appears that "Folidol-E 605" can be profitably used against the Jute Semi-looper *Anomis sabulifera* Guen. on a large scale.

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On the Effect Given by Different Preparations and their Rates of Applications in Controlling Late Blight of Potatoes (*Phytophthora infestans* de By.)

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Preparations approved for the control of *Phytophthora infestans* de By. on potatoes include a group of products based on zinc ethylene-bis-dithiocarbamate (white sprays)* which, in addition to the proved copper compounds, are drawing increased attention. German literature contains very little information on the question whether there is any difference in the effectiveness given by these preparations, as estimated from yield increases returned, at approximately the same level of expenditure. In tests conducted on tomatoes to compare the effect of 0.5 % copper oxychloride (45—50 % copper) with that of 0.2 % white spray washes, Dame (2) found that the copper preparation gave a better effect. Thiede (4) also established in an evaluation of 36 tests — allowance was also made for some of the following results — that copper oxychloride applied at a rate of 5 kilos per hectare produced a more favourable effect than white sprays applied at a rate of 1.5 kilos per hectare.

Dame (1), Johannes (3) and Thiede (4) have discussed numerous data given in the literature concerning the most favourable dosage of copper oxychloride (45—48 % Cu). Dame (1) obtained the largest yield increases at dosages of 4—5 kilos per hectare, and concluded that under his test conditions (1952) the limit of tolerance for potatoes was presumably reached at 5 kilos per hectare. In evaluating the results of seven experimenters, Johannes (3) concluded from the yield curves that a further increase in yield cannot be reckoned with when the dosage is raised above a rate of 6 kilos of copper oxychloride (45—48 % Cu) per hectare. The evaluation carried out by Thiede (4) showed that in 1952/53 the maximum tuber yield was obtained at a dosage of 5 kilos per hectare, and in the very rainy year of 1954 at a dosage of 6 kilos of copper oxychloride per hectare. These results led him to conclude that it would only be worthwhile increasing the rate of application to 6 kilos per hectare in those years when there is very heavy rainfall. To control *Phytophthora*, a dosage of 1.5—1.8 kilos per hectare is recommended for white sprays (Thiede, 4), because it has been established that the dosage of 1.2 kilos per hectare first suggested does not give a completely satisfactory effect. I have not come across any further papers in which a comparison is made of the effect of white sprays and copper oxychloride when applied on potato crops, and giving their most favourable dosages.

The following results recorded in 13 field tests carried out between 1954 and 1956, are published in the hope that they will serve as a contribution towards obtaining a final settlement of these questions.

The tests were carried out in accordance with a common plan, in selected fields containing equally large crops of "Bona" (5), "Heida" (6) and "Acker-segen" potato varieties, with four replications. The plots were 50 square metres

* In this publication, white sprays are always understood to mean the group of products referred to above.

in area. A preparation of the copper oxychloride group (45—48 % Cu) was applied at dosages of 4.5 and 6 kilos — also at rates of 7 and 8 kilos in one part of the tests — and a white spray was applied at dosages of 1.5, 1.8 and 2.1 kilos, also at rates of 1.2 and 2.4 kilos in 600 litres of water per spray and hectare. The application was carried out by trained personnel in 2 or 3 operations, using plunger-type knapsack sprayers. Leaving out the edges of the plots and avoiding failures as far as possible, 25 or 30 sq. metres of each plot were harvested, and the crop weighed immediately afterwards. The starch content was determined by the usual weighing method. In computing the results, the effect given by the different dosages was determined as a percentage in comparison with the untreated checks (= 100).

When an assessment is made of the average percentage yield increases in tuber weight obtained in the 13 tests following application of the different dosages of preparation (Fig. 1), it is evident that an equally good effect is given to all intents and purposes by dosages of 4 kilos of copper oxychloride and 1.5 kilos of white spray. At these rates, copper oxychloride just proved to be superior by a mere 0.69 %. The effect of white spray at a dosage of 1.8 kilos was on the average 2.34 % lower than that of copper oxychloride at 5 kilos, while the effect of white spray at a rate of 2.1 kilos was 3.52 % lower on the average as compared with copper oxychloride applied at a dosage of 6 kilos. The results obtained were very similar when a comparison was made of the average values recorded in the tests carried out each year (Table 1). The only exception was in 1955 when a 1.5 kilo dosage of white spray gave an effect 1.42 % better than that registered for a 4 kilo dosage of copper oxychloride.

However, when the effect of copper oxychloride applied at a rate of 5 kilos is compared as based on the total average with the effect of a 1.5 kilo dosage of white spray, it is found that the copper preparation gave a greater average yield increase of 4.1 %, which was by no means inconsiderable. Table 1 shows that also in the average evaluation of the results for the different test years, copper oxychloride is found to give a somewhat correspondingly better effect than white spray. Furthermore, a dosage of 1.8 kilos of white spray proved to be superior to a rate of 4 kilos of copper oxychloride, except in one case (1954).

When a corresponding study is made of the results obtained in each test — these results are not given due to the limited space available — the trend of the effect which the different dosage levels have upon the tuber yield, as evident from the average results (Fig. 1), is confirmed throughout, apart from a few irregularities.

A comparison of the effects which the dosages had upon the starch content showed that on the whole (Fig. 1), these were fairly parallel to the effects on the tuber yield, if the relatively slight differences are to be taken at all as a standard of value. In the dosage stages where 4 kilos of copper oxychloride were compared with 1.5 kilos of white spray, and so on, the copper preparation always gave the better results, whereas the white spray proved to be the better of the two in the comparison between 4 kilos of copper oxychloride and the 1.8 kilo dosage of white spray.

This means that the trend of the effect given by the different dosages is also evident in the starch yield (Fig. 1), so that these results need not be discussed separately.

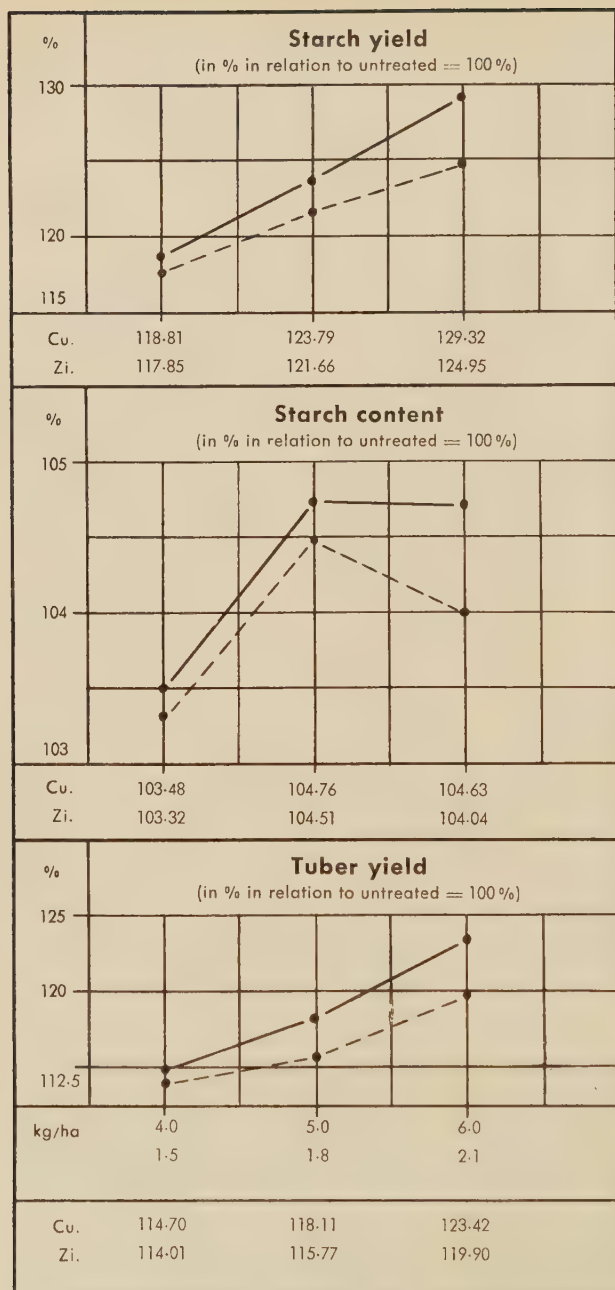


Fig. 1:

Effect of different dosages of copper oxychloride (45–48 %) and white spray on tuber yield, starch content and starch yield on the average in 13 trial controls of late blight on potatoes

Table 1: Average tuber yield in percentage, total and for each year, obtained at comparable dosages of copper oxychloride (45—48 % copper) and white spray.

Year	No. of tests	Average tuber yield increase in percentage at		Ratio of effect Copper: White spray	Average tuber yield increase in percentage at		Ratio of effect Copper: White spray	Average tuber yield increase in percentage at		Ratio of effect Copper: White spray
		4 kg/ha copper oxychloride	1.5 kg/ha white spray		5 kg/ha copper oxychloride	1.8 kg/ha white spray		6 kg/ha copper oxychloride	2.1 kg/ha white spray	
1954	3	118.63	113.53	+ 5.10	119.20	115.63	+ 3.57	124.07	121.50	+ 2.57
1955	5	114.09	115.51	— 1.42	119.49	117.18	+ 2.31	122.74	117.61	+ 5.13
1956	5	112.94	112.79	+ 0.15	116.05	114.43	+ 1.62	123.72	121.23	+ 2.49
1954—56	13	114.70	114.01	+ 0.69	118.11	115.77	+ 2.34	123.42	119.90	+ 3.52

When a comparison of costs* is made, it is found that a dosage of 4 kilos of copper oxychloride per hectare and spray is DM 1.60 cheaper than a dosage of 1.5 kilos of white spray per hectare, which is practically just as effective as the copper preparation. At dosages of 5 kilos of copper oxychloride per hectare and 1.8 kilos of white spray per hectare, the advantage in price of the copper preparation is not so large because the increase of 1 kilo of copper oxychloride does not quite correspond to that of 0.3 kilo of white spray for the compared quantities of active ingredient. Accordingly, however, the difference in effect also increases in favour of the copper preparation in the comparison of the dosages raised in stages of 1 kilo and 0.3 kilo, respectively, as proved by the results of the total average (Fig. 1). Assuming that in an ideal case there is a uniform increase in the effect of a 4—6 kilo dosage of copper oxychloride and of a 1.5—2.1 kilo dosage of white spray, a yield increase averaging about 4.36 % would be computed for each increase in dosage by 1 kilo of copper oxychloride, and an average yield increase of 2.95 % for each increase in dosage of 0.3 kilo of white spray (see Table 1). Under the conditions prevailing in the tests carried out, the average yield increases recorded showed that copper oxychloride gave a slightly better effect, and this advantage was maintained up to the maximum dosage. Past experience was thus confirmed and widened.

All 13 tests carried out between 1954 and 1956 showed that on the average both test preparations gave an appreciable increase in the tuber yields, when applied at dosages of up to 6 kilos of copper oxychloride and 2.1 kilos of white spray, respectively. The corresponding evaluation of the tests for each separate year also showed without exception that dosages of up to 6 and 2.1 kilos per hectare, respectively, gave an increase in the tuber yields. The increase rate for an average of 0.3 kilo of white spray was somewhat lower than that for 1 kilo of copper oxychloride, just as in the result for the total average. When a tuber yield calculated at 25 000 kilos per hectare, as obtained on the average in these tests, is taken as the basis with respect to the economy of the yield increases from stage to stage (3—4 % depending upon the preparation), this would mean that for the increased costs, there was an advantage of about DM 40 to 60 for 1 kilo of copper oxychloride with three sprays, and a market value of DM 8 per 100 kilos of potatoes. The percentage effect of the dosage increases from 5—6 kilos of copper oxychloride averaged at 4.41 %, and from 1.8—2.1 kilos of white spray averaged at 4.28 % was shown by the tests to be actually greater than for the increases from 4—5 kilos and 1.5—1.8 kilos, respectively. It was only in 1954 that the first increase from 4—5 kilos was the most effective, but also in this year the effect on the yield increase remained economical.

A study of the results recorded in each test showed that in eleven cases, a dosage of 6 kilos of copper oxychloride gave a better tuber yield than that obtained following an application at a rate of 5 kilos per hectare. In two tests, the yields were approximately the same for both dosages.

In ten of these tests, a dosage of 7 kilos of copper oxychloride per hectare was also tested. These tests showed that on the average this dosage gave a further yield increase of 2.43 %. Theoretically, this increase rate is also economical, but it requires further study because the individual tests showed a decrease in two cases, and an increase in seven cases. In one instance, the

* Market price in 25 kilo batches, February. 1957:

Copper oxychloride DM 4.10 per kilo; White spray DM 12.— per kilo.

yields were practically the same. In three tests, all carried out in 1954, dosages of 8 kilos of copper oxychloride per hectare and 2.4 kilos per hectare of white spray, respectively, were applied. At these high rates, a decrease was established in all cases in comparison with the next lower dosage, these decreases amounting on the average to 2.63 % for copper oxychloride and 4.33 % for white spray.

In contrast to the effect on the tuber yield, a maximum effect on the starch content was already produced at dosage of 5 kilos and 1.8 kilos per hectare, respectively. But in comparison the decrease in starch content at the next higher dosages of 6 kilos and 2.1 kilos was slight. It is evident from this that, on the average, the most favourable influence on the starch yield was at these maximum test dosages.

When the effect of the preparations is compared for the different varieties, it is found that the increasing trend in effect was uniform for all test varieties up to dosages of 6 kilos of copper oxychloride and 2.1 kilos of white spray, respectively. Without intending to overestimate the value of this finding, it may be of interest to note that there were certain gradual differences in the influence exerted by comparable dosages of preparation on the tuber yield. The differences in the effect of copper oxychloride and white sprays on the "Bona" and "Ackersegen" varieties were smaller than on the "Heida" variety. In the case of the latter variety, the weaker effect of white spray was more evident. However, no purpose would be served by entering into further discussion on this finding until more detailed studies have been conducted.

In relation to the m % generally accepted in root crop tests, the difference in yield brought about by the effect given at the various dosage stages for each preparation is really slight, particularly, however, when compared with the effect of those dosages of the different preparations, which are comparable with respect to costs. The trend of the effect evident from the results of the individual tests and also, in particular, from the average calculations seems to be so uniform, however, that an evaluation of the given results may appear justified.

In the evaluation of *Phytophthora* controls, the result has more than once (Dame, 1; Thiede, 4) been modified to make allowance for the conditions in the test area, chiefly with respect to rainfall. Such modification appears advisable also for the findings reported until further confirmation is obtained particularly as there was unusually heavy rainfall in the test area (south Westphalia) in 1954 and 1956 between June and September, a critical period for the development and control of *Phytophthora*. Table 2 gives the rainfall recorded at Arnsberg, the centre of the test area. The corresponding mean values

Table 2: Rainfall recorded at Arnsberg from June 1 to September 30, in millimetres.

40-year mean	1954	1955	1956
350.0	373.6	308.9	450.4

calculated over very many years for the test locations differ from those of the area centre by up to 20 mm in ten cases, and up to 60 mm in three cases. The differences in the values recorded at the locations during the test years are also appreciable. Naturally, it is difficult to establish definitely the influence of amounts of rainfall on the effect of *Phytophthora* controls because temperature, relative humidity, amount and intensity of sunshine, number of rainy days etc. are all factors of probable importance.

A study of the results (average and individual), from the aspect of the amounts of rainfall, did not provide any definite indication that the preparations and their dosage stages acted differently in the drier Summer of 1955 as compared with 1954 and 1956. It was merely in the case of white spray that the effect of a 1.5 kilo dosage per hectare was found on the average to be somewhat better than that of a 4 kilo dosage of copper oxychloride per hectare, but not at the higher comparable dosages. In 1955, the yield increase obtained was only slight when the dosage of white spray was raised from 1.8—2.1 kilos per hectare. It remains to be found, however, whether these findings have any connection with the smaller amounts of rainfall recorded in 1955. The trend in the effect of copper oxychloride did not differ appreciably from that in rainy years, apart from the case mentioned. In all years, the most favourable dosage with respect to the tuber yield was 6 kilos for copper oxychloride and 2.1 kilos for white spray. In 1955 when there was less rainfall, the tested dosage of 7 kilos of copper oxychloride per hectare in fact gave maximum tuber yields in all tests (5). These yields were 4.2 % greater on the average than those obtained following a dosage of 6 kilos per hectare.

A probable explanation for the fact that the highest starch content was obtained at lower dosages (5 and 1.8 kilos per hectare, respectively) is that the next higher dosages may have had a phytotoxic effect or have affected the formation of starch without this being evident from the state of the plants. It can hardly be assumed that the maximum of starch formation had already been reached at these dosages due to the fungicidal effect, because the *Phytophthora* disease could not be completely prevented in the tests. It is known that copper oxychloride is likely to have detrimental and weather-dependent effects which may increase proportionally as the dosages are raised. As far as I know, such observations have not been made following applications of white sprays on potatoes. It is possible that the slight drop in the increase of starch content at dosages of 6 kilos and 2.1 kilos, respectively, indicates that the fungicidal effect of the preparations is greater than certain phytotoxic effects on the plant, or that the starch production itself is already limited due to the increased amount of tubers.

The observation that the increased yields obtained begin to drop again from a certain limit dosage of copper oxychloride onwards, may be interpreted to mean that from this limit upwards the fungicidal effect of the preparation is exceeded by its phytotoxic effect on the plant. This limit will vary to a certain extent depending upon the respective conditions of cultivation. For copper oxychloride, this limit was always found to be below 8 kilos per hectare in all cases where this dosage was tested. In ten tests, it was below 7 kilos per hectare in two instances, at 7 kilos in one, and over 7 kilos in seven cases. In this

connection, it is interesting to note that also at dosages of 2.4 kilos of white spray per hectare, there was a drop in the yield increase as compared with the next lower stage, in all cases. This suggests that there is a similar limit to the practical effect also for white spray.

Summary

1. The results of 13 trial controls of *Phytophthora* carried out between 1954 and 1956 with comparable dosages of a copper oxychloride (45—48 % copper) spray and a white spray, have been evaluated.
2. At all dosages tested — corresponding costs were approximately the same — copper oxychloride gave on the average a slightly better effect with regard to the increase of the tuber yield, starch content and starch yield.
3. The most favourable dosage with respect to the yield of tubers and starch was found on the average to be 6 kilos per hectare for copper oxychloride and 2.1 kilos per hectare for white spray. The average results of ten tests in which rates of 7 kilos of copper oxychloride per hectare were also applied, showed that these dosages gave the average maximum tuber and starch yield. At dosages of 8 kilos of copper oxychloride and 2.4 kilos of white spray, tested in three trials, the yield increase was not so large as that recorded for the next lower dosages.
4. In contrast to the influence on the tuber yield, the maximum and most favourable increase in the starch content was already obtained at dosages of 5 kilos of copper oxychloride and 1.8 kilos of white spray.

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The Biology and Control of the Broadbean Weevil

(*Bruchus rufimanus* Boh.)

(De levenswijze en de bestrijding van de tuinboonkever)

Versl. Landbouwk. Onderz. No. 6210. 75 pages, 23 tables, 18 illustrations
Den Haag: Staatsdrukkerij Uitgeverijbedrijf 1956

This publication is the result of many years of studies conducted by the author, to compile data on the biology, economic importance and control of the broadbean weevil. In contrast to van der Vliet (1953) who in agreement with Speyer (1949), considers a control of the larvae immediately prior to their emergence to be extremely effective, Franssen has concentrated his attention on the control of adult weevils which have migrated from their winter quarters to the bean fields to lay eggs. Whereas the control of the larval stage must be carried out as soon as the dark head of the embryo glitters through the membrane of the egg, which means that a close observation must be kept on eggs laid on the pods by using a magnifying glass, the control of the adult weevils is started when the first bean flowers shed their petals, in other words at the end of the bloom period when the first pods are formed and the weevils come out to lay eggs.

Making allowance for these points, the author first deals with the flowering phenology of broad bean varieties chiefly grown in the Netherlands. Appreciable differences were established among the different varieties and also among the plants of one particular variety with respect to the time and duration of the bloom period. A detailed description of the biology of the pest is preceded by a section dealing with the injury to bean seeds caused by the larvae of the weevil. Both sections are very well illustrated by the inclusion of numerous photographs of a high instructional value. The author goes on to discuss the phenology and maturity feeding, the distribution and habits of the weevil in the bean fields, followed by details of observations on the commencement and duration of oviposition on the plants. Numerous seed tests revealed that a wasp species, *Triaspis gibberosus* Szepi., is a natural enemy of the broadbean weevil, and occurs as a parasite of the larval stages especially in the southern part of the country.

In the section dealing with the economic importance of the pest, stress is laid chiefly on the effects which weevil attacks have upon germinating capacity in seed production, whereas a loss of weight is the only symptom of attack established when fodder beans are harvested. Observations made by field workers that seeds containing one or two bored holes are able to germinate better, were not confirmed by the studies conducted. Rathermore, it was proved that the germinating capacity of attacked seeds depends upon whether the germinating organisms have been damaged or not by the feeding of the pest. In certain areas of the Netherlands, *Bruchus rufimanus* causes serious damage every year, whereas in other parts there is a varying degree of occurrence. Early blossoming varieties are more heavily attacked than those which bloom late; broad bean varieties, in particular, belong to the early blossoming group. Seed infestations of up to 50 % are frequent in the Nether-

lands, and therefore it is very important that measures are taken to control the pest. The author discusses the possibility of controlling weevil occurrence by growing late blossoming varieties, sowing in late season, introducing mixed cultivation of beans and other crops (also suggested by Liebster, 1941), and crop rotation. Chemical control is dealt with in detail, especially the control of adult weevils which colonize the young plants to lay eggs. Field trials with different contact insecticides were carried out at several places between 1953 and 1955. The tests revealed that the best results are obtained with DDT, Parathion and Dieldrin preparations applied at rates of 2 kilos, 0.4 kilo and 0.47 kilo active ingredient per hectare, respectively. Preference should be given, however, to the Parathion preparations because they give simultaneous control of *Doratis fabae* Scop. and have a slight residual effect. One spray application is sufficient. It is not advisable to spray at temperatures below 17° C. In the closing section, the advantages and disadvantages of controlling the weevils and the egg stage are again discussed.

The list of references includes more than fifty papers on the biology and control of this pest, published in Italy, Japan, Canada, the Netherlands, South Africa, the U.S.A. and Germany. The appendix contains several tables of results obtained in field tests, in further explanation of the facts given in the text.

Dr. W. Kolbe

In Memoriam Prof. Dr. Albert Boerger

One of the most outstanding personalities engaged in agricultural research in South America, Prof. Dr. Albert Boerger, died on March 28th, 1957, in Uruguay. Many were the honours which had been bestowed upon Prof. Dr. Boerger, but he passed away shortly before being awarded the greatest distinction of his life. On May 17th, the Instituto Fitotécnico y Semerillo Nacional "La Estanzuela", which he founded in 1912 at the request of the Uruguayan Government, and which attained international repute during the 45 years under his uninterrupted supervision, was to be given his name. His very many scientific works on grain cultivation in South American climates and his breeding of cereals and other agricultural crops constituted valuable pioneering work and paved the way for the development of agriculture in Uruguay and neighbouring countries.

A. Boerger who was born at Foerde in Westphalia, Germany, concentrated his attention on natural science and philosophy during his studies of agricultural subjects at Hannover, Bonn and Giessen, and graduated with the degree of Dr. phil. In 1910, at the age of 29, he returned after spending many years of practical work on seed production in Germany, to Bonn where he cooperated at the Institute of his tutor, Prof. Dr. Remy.

In 1912, he accepted an invitation of the Uruguayan Government to establish an Institute for Plant Cultivation and Plant Breeding in Colonia. In his capacity as organizer, research worker, pedagogue, pioneer and author, Prof. Dr. Boerger rendered an outstanding service to agriculture in his second

home-country, and in fact throughout the whole of South America. He published over 400 scientific treatises which earned him fame in the entire scientific world. Worthy of special mention is his work in three volumes on agricultural studies (1943). His international reputation is reflected in the numerous honorary posts which he held in Research Organizations and Societies. In recognition of the services of their former member, the University of Bonn awarded him an honorary doctorate on July 12, 1954. Until his death, Prof. Dr. Boerger maintained personal and professional relations with Bayer Plant Protection. He will remain unforgotten among his friends both as a person and as a scientist of great renown.